THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. IV.

No. XII.—DECEMBER, 1887.

ORIGINAL ARTICLES.

I.—On a New Specimen of *Solaster Murchisoni* from the Yorkshire Lias.

By Prof. J. F. Blake, M.A., F.G.S.

(PLATE XV.)

THE specimen to which the following description applies was found by the Rev. G. Crewdson, F.G.S., of Kendal, at the base of the cliff at Huntcliff. The block in which it lay was separated from the parent rock, and had doubtless fallen from above. The occurrence in the same slab of a portion of an arm of *Ophioderma Milleri* and the general character of the stone leave no doubt that it is derived from the "Star-fish" bed of the Capricornus Zone.

The only other known examples of polyradial star-fish from the Yorkshire or any other Lias are figured on plate v. of Dr. Wright's Monograph of Oolitic Asteroidea in the Palæontographical Society's volume for 1861, issued in 1863. These are named *Plumaster ophiuroides*, and *Luidia Murchisoni* respectively. That our fossil is not the same as the former is very evident from its possessing 22 arms instead of 14, and other differences are soon observed. On comparison with the latter, as represented by its figure and description, it appears very closely allied; but this is described as a *Luidia*. The principal difference between a *Luidia* and a *Solaster*, that can be observed on such examples, is that in *Luidia* the ventral surface of the arms has one medial row of ossicles, with the pores on either side, whereas in *Solaster* there are a pair: a circumstance that results in dried specimens of the latter opening along the ventral side of the rays, while in the former the rays remain intact. Now, on examination of our specimen, it is immediately evident that in this respect it agrees with *Solaster*. Therefore, if the specimen described by Dr. Wright is a *Luidia*, this cannot be the same. This was my opinion when I exhibited the specimen at the British Association at Manchester in September last. But on that occasion Prof. Williamson, who found the specimen figured by Dr. Wright, and also provided the description, considered the new specimen so like the old, that a comparison became necessary. Through the kindness of Mr. J. Woodall, I have been enabled to examine the other specimen in the Scarborough Museum, as it was found to be in too fragile a condition for safe carriage. The result of that

examination is that they are undoubtedly of the same species, and that therefore they both belong to the genus *Solaster*.

The new example, however, is so much better preserved, and renders the possible description so much fuller and more accurate, that it is worthy of as much consideration as if it had been a new species. I shall therefore describe it fully.

SOLASTER MURCHISONI, Williamson (sp.).

Syn. 1836. *Luidia Murchisoni*, Williamson, Mag. Nat. Hist. vol. ix. p. 425.
,, 1855. *Solaster polynemia*, Simpson, Fossils of the Yorkshire Lias, p. 135.
,, 1863. *Luidia Murchisoni*, Wright, Palæontographical Soc. p. 111, pl. v. fig. 2.

Diagnosis.—Diameter 4–6 in. Central aperture $\frac{1}{6}$ diameter. Rays 20–22. Angle-plates long, triangular. Ambulacral area with a pair of ossicles, anvil-shaped. Pores large. Interambulacral area half clothed, ossicles 5 on ventral surface, each with a spine, terminal one with two. Dorsal surface with branching ossicles loosely netted.

Description.—The new specimen is about 4 in. in diameter. It has been buried in the stone with its ventral surface downwards, by which means an external cast has been produced of the ventral surface of its arms. Upon this has been pressed down the dorsal surface which covers over and hides the central opening, and shows sharply marked triangular, or bent impressions irregularly scattered, which are interpreted as the casts of a loose network of dorsal ossicles. The arms are 22 in number (see Fig. 1). Some are broken, but most are complete, and come to a rather blunt termination. Along the centre of each (see Fig. 2) is seen a raised band, corresponding to a depression in the animal. This band is threefold, the centre line is the interval between the ambulacral ossicles, which are like anvils placed back to back, as seen in the depressions of the cast. The pores are large and form the two outer bands, occupying the concavity of the ambulacral ossicles. Each of these ossicles is continued outwards and also somewhat radially by a subtriangular ossicle—and then by four others—all of the interambulacral series. Each of these four had a spine in its centre, and the outermost an additional larger one at the end. These latter clothe the sides of the rays with a layer of spines. It is possible there were smaller spines also on the softer part which intervened between each of these rows of interambulacral ossicles and the next. These rows form cross lines in the cast, with a gentle concavity in the radial direction, and each ray has nearly 50. In one spot a fragment of a ray has been reversed and its dorsal surface is seen. This shows the insertions of the spines at the sides; but the remainder is so smooth that the paxillæ must have been very small. This is all that can be learnt from this specimen, which is beautifully preserved in a fine micaceous, earthy sandstone, well suited to retain impressions.

The original specimen, now in the Scarborough Museum, under the charge of Mr. Phillips, who gave every facility for its examination, is in a shaly matrix, which, in spite of preserving materials, has cracked, and is very liable to shale off entirely. It shows 20 arms and the central aperture is well-preserved, being about $\frac{1}{6}$ of the whole diameter. The inner ends of the rays open out in the

ambulacral line, and on either side is found a projecting triangular ossicle, whose cast is well preserved. These are thus arranged in closely opposed pairs in the interambulacral line (see Fig. 4). The features of the ventral side of the rays are not well preserved; but in four places at least the casts of the pair of ambulacral ossicles are seen, and they are of the same shape as in the new specimen (see Fig. 3). The somewhat separated rows of interambulacral ossicles are preserved as grooves, in the base of which are seen the pits which indicate the spines. The larger ones at the ends are also marked by the marginal pits, and the casts of the spines themselves are seen diverging from them. Towards the margin of the central aperture is seen the madreporiform tubercle which, with the exception of the casts of a few ossicles, is the only relic of the dorsal surface that is preserved. This is beautifully shown, it is of the ordinary type with radiating pores, and it is about $\frac{1}{10}$ inch in diameter (see Fig. 5).

It is thus seen that in all comparable points the two specimens agree, while each contributes something special to the description, which between them is rendered about as complete as we can well expect in the case of such an ancient relic of the group. The new specimen is now one of the ornaments of the Kendal Museum, whose development the discoverer has done so much to promote.

DESCRIPTION OF PLATE XV.

Fig. 1. New specimen of *Solaster Murchisoni*, in the Kendal Museum. Found by Rev. G. Crewdson in the Capricornus beds of Huntcliff. Natural size.
,, 2. Portion of a ray of the same restored. Enlarged.
,, 3. Ambulacral ossicles of the type specimen. Enlarged.
,, 4. Angle plates at the inner ends of the rays of the type specimen.
,, 5. Madreporiform tubercle of the type specimen. Enlarged.

II.—Gastaldi on Italian Geology and the Crystalline Rocks.[1]

By T. Sterry Hunt, M.A., D.Sc., LL.D., F.R.S.

THE present writer in 1883 reviewed the history of the rocks of the Alps and the Apennines with especial reference to the geological relations of serpentine and its associates, in a paper which appeared in the first volume of the Transactions of the Royal Society of Canada, and is reprinted, revised and with some additions, as the tenth chapter of his volume entitled "Mineral Physiology and Physiography" (Boston, 1886). Therein he gave a somewhat detailed account of the labours in Italian geology of the late Professor Bartolomeo Gastaldi, of Turin, a list of whose publications on that subject from 1871 to 1878, so far as known to the writer, will there be found, including his letter to Quintino Sella, in 1878, on the general results of explorations made in 1877 (*loc. cit.*, 458). In doing this the present writer said, "I feel that I am both rendering a veritable service to science and paying a tribute to the memory of my honoured friend and correspondent of many years," stating at the

[1] Read before the British Association for the Advancement of Science, Section C, Manchester, Sept. 4, 1887.

same time that "the work of Gastaldi, interrupted by his death in 1878, was unfortunately left incomplete." This statement was not quite exact in one particular, since he survived till January 5, 1879, when there passed away, universally honoured and beloved, one who brought to the study of geology, with a spirit of complete devotion, a rare genius and a breadth of view which will assure him a first place among the geologists of our time.

In the chapter above mentioned the writer proceeded to consider the history of the so-called Tertiary serpentines of Monte Ferrato in Prato (Tuscany), and those of parts of the Ligurian Apennines which he had personally examined, and, in opposition to the opinion of most Italian geologists, and some others who have studied them, maintained that they were really but portions of the ancient *pietre verdi* zone, identical with that of the Alps, underlying, in the regions in question, the beds of Eocene age; which latter, by subsequent terrestrial movements, have been disturbed, broken and even inverted, so as to seem to pass beneath the serpentinic rocks. The indigenous and neptunian character of serpentine, maintained on stratigraphical evidence in North America by E. Emmons, by Logan, and by the present writer, was not only held by Gastaldi and Delesse, but is maintained by Stapff, by Lotti, and by Dieulefait. The hypothesis of a plutonic origin has moreover been so much modified by recent Italian geologists, as Taramelli, Capacci, Issel, and Mazzuoli, that instead of supposing them to have been erupted like basalts, they now conceive that serpentines, and the associated rocks of the ophiolitic group, were formed by submarine eruptions, in Tertiary time, of magnesian and feldspathic muds, of unexplained origin but of no very elevated temperature; which subsequently consolidated and crystallized into euphotide, diorite, and serpentine, with their associated feldspars, enstatite, chrysolite, and other minerals.

In the change of chrysolite into serpentine, as I have elsewhere shown, "one hundred parts by volume of the former species, with a specific gravity of 3·33, if converted into serpentine of specific gravity 2·50, without change in its content of silica, must lose one-eighth of its weight of magnesia, and acquire the same amount of water instead, while at the same time its volume will be augmented one-third, or to one hundred and thirty-three parts." That such a change takes place in some instances, probably through the action of carbonated waters removing a portion of magnesia from chrysolite, and leaving behind the more stable hydrated and colloid silicate, serpentine, is evident. Until, however, the precise conditions under which this may take place are better understood, we cannot explain why in some cases chrysolite is exempt from such change. I have long since described in the vicinity of Montreal, in Canada, cutting the limestones and pyroschists of the Ordovician series, great masses of a granitoid chrysolitic dolerite, itself of Palæozoic age, in which the chrysolite, in large crystals, often predominates, and is still unchanged, hard, and anhydrous. The assumption, lightly made by some plutonists, that chrysolite is always of plutonic origin, and serpentine always a product of epigenesis, rests upon a slender foundation, and is in

contradiction with a great number of facts. While the production of chrysolite from mixtures in a state of igneous fusion is well known, and while the chrysolitic rocks just mentioned are, as I have endeavoured to show, the result of crystallization and partial eliquation in a truly plutonic mass, it is not less certain that to other chrysolitic rocks a neptunian origin must be assigned; as was maintained by the writer in 1879, for the so-called lherzolite or chrysolite-rock which, accompanied by enstatite, serpentine, and chromite, is interstratified with the younger gneissic and mica-schist series in North Carolina. The same may be said of the similar chrysolite rocks in Norway, which, like these, are gneissic in structure and interstratified in crystalline schists. In this connection I have also elsewhere noted the variety of chrysolite known as glinkite, found in nodules in talcose or micaceous schists in the Urals, and that purely magnesian chrysolite or forsterite which occurs abundantly in crystalline limestone in eastern Massachusetts. It appears evident that chrysolite, like pyroxene, feldspars, spinel, and many other species, is generated alike by plutonic and by neptunian agencies.

As regards serpentine, while it may occur as a product of the decay of chrysolites either of igneous or of aqueous origin, no one who has intelligently studied the mode of its occurrence in grains, nodules, interstratified layers and beds, sometimes hundreds of feet in thickness, in the crystalline limestones and dolomites of Archæan rocks alike of Laurentian and of Taconian age, and even in Palæozoic strata, can doubt the direct formation of serpentine and its accompanying silicates, in such cases, by aqueous deposition. Its separation from solutions is also made apparent by the frequent occurrence of veins carrying the species marmolite and chrysotile (which are but crystalline forms of the same silicate as serpentine) either with or without calcite, traversing ophiolitic rocks, and even, as noticed by Gastaldi, in serpentinic breccias of comparatively recent date.[1]

Gastaldi had already, in 1871, expressed in general terms his opinion that "all the serpentinic masses of the Tuscan and Ligurian Apennines," as well as the similar rocks in Calabria, are but prolongations of the great pietre verdi zone of the Alps, in which he included what are known as the Apuan and the Maritime Alps. To the same horizon also he referred the so-called ophitic rocks of the Pyrenees. From my own observations in Italy in 1881, I could not doubt the correctness of these earlier generalizations of Gastaldi, who however apparently did not verify his conclusions by personal observations of the so-called Eocene serpentines of Liguria and Tuscany until 1878, a few months before his death, when he examined both of these regions with especial reference to the question. His final conclusions thereon, a fortunate circumstance now permits me to give to the world.

There lies before me a letter of eleven pages, to my address, from

[1] For a detailed discussion of the questions here raised as to serpentine and related silicates, see The Genesis of Serpentine, in the author's Mineral Physiology and Physiography, pp. 497–509; also further for analyses and description of the chrysolitic dolerite, *ibid.* pp. 211–213.

Gastaldi, written in French, and dated Turin, July 20, 1878, which reached me in London in due time. After reading the first and last pages of this epistle, concerning matters which demanded and received an immediate answer, it was put aside for careful perusal, and by a curious chance was mislaid, and believed to be lost until recovered during the present year (1887). As it is the last recorded word of Gastaldi with regard to various geological problems which had occupied many years of his life, and moreover sustains fully my own opinion formed three years later regarding the rocks in question, as set forth above, I have thought it well to translate into English this precious letter, omitting only those portions which have no reference to the subject before us,—premising that with the exception of the references to the regions then lately examined by him, the conclusions, for the greater part, are already embodied in his previously published papers and in the present writer's summary of them :—

"Turin, July 20, 1878.

"Dear Friend and Colleague,—On returning from a long campaign in the Apennines of Prato (Tuscany) and the Apennines of Liguria, I was agreeably surprised to receive your letter from Montreal of June 25, announcing your speedy departure for England. . . . . I am very glad that you are about to give us a historical and critical work on the Azoic rocks of North America, respecting which it has not been easy to get clear ideas, on account of the extent of the literature and the difficulty of procuring it. I agree with you that we are now enabled to place on a solid foundation the classification of the Azoic rocks, and you may rely on my support of your views which you will lay before the International Geological Congress, where your skill in exposition will be more effectual, because the facts are evident. I cannot myself attend the Congress, for at that time it is necessary that I should be in the high valleys of the Maritime Alps; besides which please consider that I am sixty-one years of age, and cannot put off labours which involve great fatigue, and of which I may not be capable another year. . . .

"You propose to give in your volume my conclusions as to the crystalline terranes of the North of Italy. For this I thank you with all my heart, and demand permission to set forth a summary of my observations.[1] As to crystalline rocks, I am even more radical than you; for me all crystalline rocks are stratified; for me there is no plutonism; for me volcanic activity commenced only with the lavas of the Lower Tertiary; at least I know no intrusive rocks in the Alps; the porphyries there are, to my eyes, sedimentary.[2] I

[1] The volume here referred to was that on Azoic Rocks, being Report E. of the Second Geological Survey of Pennsylvania, 1878 (8vo. pp. xxi. and 253), and was already printed at that date, a point which I had apparently not made clear to Gastaldi, who sent the notes for the volume in question, as well as for use at the Geological Congress of 1878, where, however, the time had not yet come for their presentation. The volume on Azoic Rocks contains a brief summary of the views of Gastaldi, drawn from his published papers.

[2] I have elsewhere remarked that Gastaldi, misled by his too exclusive Wernerianism, appears to have included under the name of porphyry both stratified neptunian rocks and intrusive plutonic or pseudoplutonic rocks of more than one kind.

divide the crystalline rocks into two great zones; the lowest consisting of the oldest rocks of the Alps, and probably of the globe, is that of the central, ancient, or primitive gneiss. It is emphatically the zone of the orthoclase feldspar, and is very poor in minerals. The other zone is that of the *pietre verdi*, or green rocks, and is especially the zone of the triclinic feldspars, like those of the diorite, euphotide and apenninite. The granites themselves of this zone—and I cite those of Elba, of Baveno, of Mont Orfano, and of Alzo, etc.—although characterized by the beauty of their crystals of orthoclase, are rich in albite. I have cited apenninite, which will be new to you, so that I give the following explanation. Our geologists have long recognized in the Apennines of Savoy the presence of a great body of protogine or protogine-like gneiss. This rock is composed of quartz and feldspar, in nodules rather than in crystals, and of chlorite. A rock of the same character has been recognized by Giordano in the Grand Cervisa. Now the feldspar of this rock, which in the Ligurian Apennines, as well as in the Pennine Alps, occupies a large surface, is in part soda-bearing, and I have thought best to distinguish it from the true protogine, the feldspar of which is orthoclase, by the name of apenninite.

"In a great many localities in the Alps we see the pietre verdi resting against the central gneiss, but in others the same series is found lying nearly horizontally thereon. In the latter case meteoric agencies destroy this superimposed series, and thus extend more and more the area of the ancient gneiss, already widely exposed. Were the rocks of the pietre verdi zone thus made to disappear from the Alps, the height of these in many places would be much reduced (thus, for example, the Grand Cervisa and the Grivola are formed of this zone); and when at last these rocks were destroyed, we should find the region entirely occupied by the ancient gneiss. In a word, the mass of the Alps is formed of the ancient or primitive gneiss, here and there overlain by the rocks of the pietre verdi zone."

[For illustration of these different relations two figures are given in the letter, one of which is along the valley of Lanzo, showing the stratified pietre verdi series resting at a considerable angle upon the ancient gneiss (the stratification of which is not indicated), and overlaid by more recent sediments. The other section, in the valley of Chisone, represents the ancient gneiss overlaid by a stratum of lherzolite, one of serpentine, and one of diallagic euphotide, the attitude of all three being nearly horizontal.]

"The ancient gneiss is very poor in minerals, but includes a limited number of other rocks, such as quartzite, amphibolite, and crystalline limestone. The zone of the green rocks or pietre verdi, on the contrary, is very rich in minerals, as well as in varieties of rocks. Whence have come the minerals of this zone, since they have not [apparently] traversed the gneiss? Whence the porphyries and the granites of this same zone, which we nowhere find intersecting the gneiss? We must conclude—and direct observation of the facts demonstrates it—that the masses, the veins, and the so-called bedded veins in which the zone of the pietre verdi is so rich, are

characteristic elements of these rocks, and do not come from great depths. The porphyries and the granites, which are found so frequently in this zone, are not intruded rocks, since they do not traverse the underlying gneiss, but of sedimentary origin, like the limestones, the calcareous and argillaceous schists which accompany them. These are points upon which it seems to me important to insist.

"At Chaberton, a mountain of the Cottian Alps, I found resting directly upon the serpentinic series a semi-crystalline limestone holding organic remains. Not then suspecting a hiatus in the succession, I was led to suppose that these fossils, which were badly preserved, might be very ancient, and my friend Michellotti, who was so good as to study them, thought like myself that they were Lower Palæozoic forms. Upon these fossils I have published two papers.[1] It appears, however, that our notion of the existence of Silurian [Cambrian] forms in the Alps was an illusion.[2] I subsequently discovered more complete sections in the valley of the Macra, and in that of the Stura de Caneo (Maritime Alps), and in these, in limestones which appear to be a continuation of those of Chaberton, we have found a good number of fossils which have been described by Messrs. Zittel and Gümbel, and show the existence in the Alps, above the zone of the pietre verdi, of various Mesozoic and Cænozoic terranes. Resting upon the crystalline rocks we have, first a quartzite alternating with a semi-crystalline limestone, then a compact limestone with layers of anthracite, followed by another compact limestone of Triassic age, with *Encrinurus liliiformis*, and finally by a series of limestones, Liassic, Jurassic, and Cretaceous; the whole overlain by Nummulitic and more recent Tertiary strata. The complete succession is then (1) The ancient central or primitive gneiss, with quartzite, crystalline limestone, graphite, etc. (2) The pietre verdi series, principally formed of serpentine, lherzolite, euphotide, diorite, variolite, porphyry, calc-schists, apenninite, etc.; (3) The anthracitic series; (4) Triassic; (5) Liassic; (6) Jurassic; (7) Cretaceous; (8) Nummulitic, Miocene, Pliocene." [This is illustrated in the letter by an ideal section.]

"The excursions which I have lately made in the Apennines of Prato in Tuscany, and in the Ligurian Apennines, had for their object to study the serpentines of these regions. Some geologists of my acquaintance have lately given themselves much labour and pains to confute my views of the age and the nature of the serpentines. They wish to establish that these are eruptive rocks, in many cases interstratified with the beds of the Upper Eocene—a proposition which is wholly untenable. The serpentines as well as the other rocks of the pietre verdi series are ancient rocks, pre-Silurian in age, and are of types which have not been formed in later times. In regarding these from this point of view, the geology of all those

[1] Sul fossili del calcare dolomitico del Chaberton; Roma, 1876. Su alcuni fossili paleozoici delle Alpi marittimi et dell' Apennini ligure; Roma, 1877.

[2] In Sardinia, however, Lower Palæozoic forms, both Cambrian and Ordovician, are met with; Mineral Physiology and Physiography, p. 476.

regions in which the pietre verdi series plays an important part becomes easy to understand; but it is, on the contrary, extremely complicated if we consider the rocks of this series as intrusive. In a great many parts of the Alps we see these rocks rising into considerable elevations, as in Monte Viso; elsewhere again they are overlain by the anthracitic series, by the Trias, or by still more recent terranes. Thus in the valleys of the Bormida, and the Erro, and in other valleys of the Ligurian Apennines, they are directly covered by the Miocene; and again, as in the Apennines of Bologna, of Florence, etc., are overlain by the Eocene or the Upper Cretaceous. The separation of the two chains, Apennine and Alpine, is but a geographical fiction; it would be absurd to attempt to separate them geologically. I have visited the valleys and the depressions along which geographers have drawn the lines of separation, and have there found nothing but Alpine rocks, serpentine, apenninite, calc-schists, etc. . . .

"To-morrow I leave for the Maritime Alps, where I shall remain for about a month in order to visit the valleys of the Macra and the Stura, that of Geno and that of the Vermagna, making for the third time this journey, which is a weary and a painful one, especially for the valley of the Macra, where one is forced to undergo many privations. I am delighted to think that our literary correspondence is renewed, and regret very much that circumstances deprive me of the pleasure of being with you at the Congress in Paris. . . .

"Affectionately yours,

"To Mr. T. Sterry Hunt. B. Gastaldi."

As regards the pietre verdi series, of which he has here so well set forth the importance, I have in the volume already quoted (Mineral Physiology and Physiography) shown that Gastaldi not unfrequently employed it, as in the foregoing letter, to designate the whole succession of crystalline schists above the ancient or central gneiss—speaking of these collectively as the "newer crystalline series." This however, includes a great body of younger gneiss and mica-schists above the group characterized by serpentine, euphotide, diorite, etc., which he has here so clearly defined as resting upon the ancient gneiss. Neri, in his sections in north-western Italy, distinguishes above the ophiolitic or pietre verdi horizon, a group of mica-schists with granites, while Gerlach described the same as recent gneiss and granite, followed by gneissic mica-schists. Gastaldi himself, in more detailed accounts, used the term pietre verdi in the same restricted sense as Neri. Thus in 1874 (*Studii geologici sulli Alpi occidentale*, part 2) he speaks of "the pietre verdi properly so-called," and declares it to be comprised between "the ancient porphyroid and fundamental gneiss," and "the recent gneiss, which latter is finer-grained and more quartzose than the other." He elsewhere in this same memoir speaks of this higher portion of the "newer crystalline series" (oftentimes, as in the above letter, comprehended in his "pietre verdi zone") as a mica-schist,—a gneissic mica-schist,—as recent gneiss and mica-schist,—and also as a very micaceous gneiss, often passing into mica-schist and sometimes hornblendic. He says

farther, "I will not assert that when specimens of this newer gneiss are confusedly mixed with those of the more ancient, it would always be practicable to distinguish them petrographically; but I do not hesitate to affirm that their distinction in the field is not difficult; on account of the frequent alternation of the younger gneiss with the other characteristic rocks of the upper series [micaceous and hornblendic schists, etc.], while the older gneiss, however wide its extent, is generally unmixed with other rocks."

Above this recent gneissic and mica-schist division, but below the anthracitic group, and included in the "newer crystalline series" of Gastaldi, there is a considerable thickness of crystalline schists, often soft and unctuous, and variously described as argillaceous, talcose, and micaceous, or as grey lustrous schists, which are sometimes sericitic. These, moreover, include quartzite, karstenite, dolomite, and banded and statuary marbles, with occasional serpentines and amphibolic rocks. Serpentines are also met with in intimate association with the younger gneisses, and hence Gastaldi often spoke of the whole triple group of the newer crystalline series above the ancient gneiss as the "pietre verdi zone." To each of these three divisions he, in common with other Alpine geologists, assigns a thickness of several thousand metres.

While these great divisions of the crystalline rocks were thus being defined in the Western Alps, Von Hauer had already, in 1868, shown the same succession further to the eastward, in the Lombardo-Venetian Alps, where he distinguished, first, the ancient gneissic and granitic rocks, called by him the central gneiss; second, a great thickness of green rocks or pietre verdi, including serpentine, euphotide, and diorite, with various amphibolic and chloritic rocks, together with saccharoidal limestones; and, third, a recent gneiss and mica-schist series. Gastaldi, at an early date in his studies, recognized in the older or central gneiss the Laurentian series of North America, and in the succeeding green rocks, or pietre verdi proper, the group which I had in 1855 called Huronian. It was not until 1870 that I attempted to define as a distinct and newer series the group of younger gneisses and mica-schists in North America, called by me subsequently, in 1871, the White Mountain or Montalban series, and corresponding both lithologically and stratigraphically to the recent gneiss and mica-schist series already recognized in 1868 by Von Hauer in the Eastern Alps, indicated by Gerlach in the Western Alps in 1869, and described more at length by Gastaldi in 1871. The work of none of these was known to me when, in 1870, I first set forth the distinctness of this great group of younger gneisses and mica-schists in North America, and also indicated their existence in the Scottish Highlands.

I had, in 1881, an opportunity of examining this upper gneissic series in the Western Alps, near Biella in the province of Novara, and in company with Quintino Sella (who with Berutti had carefully mapped the region), of going over a section which had been studied and described alike by Gerlach and by Gastaldi. Here, besides the ancient gneiss, with included graphitic and pyroxenic limestone, the

whole indistinguishable from the Laurentian of North America, and also the characteristic serpentinic or proper pietre verdi group overlying it, I found the recent gneiss and mica-schist series apparently overlying transversely both of these, and seemingly identical with the Montalban or younger gneissic series of the White Mountains and of Philadelphia in North America. An absence of the ophiolitic or true pietre verdi group between the older and the younger gneissic series, which is apparent elsewhere in the Alps, and in many places in North America, may be due either to non-deposition or to erosion. The existence of conglomerates holding rolled pebbles in the younger gneissic series, both in Europe and America, shows erosion to have played an important part in Archæan as in later times, and is in harmony with the observed stratigraphical discordances in the crystalline rocks, each one of the upper divisions in turn being found to rest upon the ancient gneiss.

The younger gneissic or Montalban series I have found well displayed in Mont St. Gothard and in the Ticino basin in Switzerland. To it also apparently belong the granulite rocks and the mica-schists of the Mittelgebirge in Saxony, with their dichroite-gneiss, lherzolite, and garnetiferous serpentine, and also the micaceous gneisses of the Erzgebirge, with their included limestones and amphibolic rocks, and their overlying mica-schists. In these latter are found the remarkable conglomerate beds described by Hauer in 1879, the pebbles of which are apparently derived from the ancient or central gneiss, of which they have the characters.[1]

While thus referring the younger gneisses and mica-schists alike of Saxony and of the Alps to the Montalban, I have maintained that the uppermost division of the newer crystalline series of Gastaldi is to be regarded as the equivalent of the Taconian or Lower Taconic of North America, designated by Lieber the Itacolumitic series; a great group of strata which is traced from the Gulf of St. Lawrence, with some interruptions, nearly to the Gulf of Mexico, and westward to the basin of Lake Superior and beyond. This series should be carefully distinguished from the Upper Taconic, a younger uncrystalline series, different in geographical distribution, and containing a well-defined Cambrian fauna. The Taconian or Lower Taconic, whose real stratigraphical relations were already clearly defined more than fifty years ago by Amos Eaton, has since, by various theorists of the metamorphic school, been alternately regarded as altered Cambrian, altered Ordovician, altered Silurian, altered Carboniferous, and in part even as altered Triassic;[2] a history which recalls that of the similar strata of the Apuan Alps, including the marbles of Carrara and Massa, which have by different writers been

[1] See for a detailed discussion of the questions here involved, the author's "Mineral Physiology and Physiography," on The Geology of the Alps and the Apennines, pp. 457-482; The Serpentines of Italy, pp. 482-496; and further, The Metamorphic Hypothesis, pp. 654-673.

[2] For a detailed account of the Taconic controversy see the author's "Mineral Physiology and Physiography," 517-686; also, more concisely and with new facts, "The Taconic Question Restated," Amer. Naturalist, Feb. Mar. and Apl. 1887.

referred to various horizons from Cretaceous down to pre-Palæozoic, at which latter they are placed by Gastaldi, in the upper part of his "newer crystalline series," as also by Jervis in the second volume of his valuable treatise, *I Tesoro Sotteranei dell' Italia.*

This Taconian or newest crystalline group embraces in North America besides quartzites (sometimes in flexible elastic layers) and crystalline limestones affording both banded and statuary marbles, large deposits of iron-ores, alike magnetite, hæmatite, and limonite, the latter being formed by epigenesis, in some cases from pyrites and in others from siderite. It also includes a great mass of argillites, and of soft unctuous schists, often described as talcose, and though more generally sericitic, sometimes containing chlorite and talc, together with occasional amphibolic and feldspathic rocks, massive serpentines and ophicalcites, and bearing throughout a marked resemblance to the upper division of the newer crystalline series of the Alps.

As the writer has elsewhere pointed out, the chemical and mineralogical conditions of the underlying pietre verdi horizon were repeated, though with diminished intensity, at this later time in the history of the newer crystalline series, producing in the younger rocks thereof such resemblances to the older that the Taconian strata were not unnaturally confounded with the Huronian. Thus, to the south of Lake Superior, Emmons having in 1846 recognized the Taconian, he was led, when the Huronian was announced in 1855, to maintain (in an unpublished paper) that it was in no way distinct from his Lower Taconic. On the other hand, the present writer, in common with Murray, Credner, and others, included these same Taconic rocks in that region with the Huronian, and it was not until after a prolonged study of the Taconian in the more eastern regions of North America, that he was enabled to show that the two series had really been included in the Huronian as defined in the vicinity of Lakes Superior and Huron; where also the recent gneisses and mica-schists are met with, as well as the ancient or primitive granitoid gneiss. In like manner, as we have seen, Gastaldi was led, from such lithological likenesses, to include the upper and lower division of his newer crystalline series, with their intervening recent gneisses and mica-schists, under the comprehensive name of the pietre verdi zone. These partial resemblances between the crystalline rocks of succeeding divisions serve to illustrate the different stages in the process of evolution of the crystalline rocks in successive ages by chemical agencies from an originally undifferentiated mineral matter, as I have endeavoured to set forth in a recent paper on "The Elements of Primary Geology."[1]

[1] Geological Magazine, November, 1887.

III.—On the Genus *Piloceras*, Salter, as Elucidated by Examples lately discovered in North America and in Scotland.[1]

By Arthur H. Foord, F.G.S.

THE genus *Piloceras* was founded by J. W. Salter in 1859[2] upon the siphuncle of a shell closely allied to *Endoceras*. It was supposed by Salter that the invaginated sheaths observed in the siphuncle of *Piloceras* "represented the siphuncle and septa combined," the septate part of the shell not being preserved in the specimens described by him.

A year after the appearance of Salter's memoir, E. Billings (at that time Palæontologist to the Canadian Geological Survey) described a fossil from the Calciferous Sandstone (= Tremadoc) under the name of *Piloceras Canadense*.[3] This exhibited the septate part of the shell in conjunction with the siphuncle.

The general form of this species was well characterized by Billings as that of a "short, thick, curved Orthoceratite."

This appears to have been the first discovery of the septa of *Piloceras*, associated with its siphuncle, for the generic identity of Salter's and Billings's species is now put beyond all doubt.

Again, in 1881 Sir William Dawson[4] described a new species of *Piloceras* (*P. amplum*) from the Calciferous Sandstone of Lachute, near Montreal, which threw much new light upon the internal structure of the shell.

But the most complete examples of *Piloceras* hitherto met with were collected in 1885 by Messrs. Seeley and Brainerd, at Fort Cassin, in the State of Vermont, from rocks considered to be of the age of the Birdseye Limestone (= the Lower Llandeilo, nearly). These fossils were described and beautifully illustrated by Professor R. P. Whitfield, of New York,[5] who was enabled to show by means of almost perfect specimens, the body-chamber, septa, siphuncle (in place), and even the test of the species, which he very appropriately named *Piloceras explanator*.

M. Barrande,[6] whose information about *Piloceras* was very scanty, constituted it a subgenus of *Cyrtoceras*, on account of its curvature, and Professor Blake[7] disposes of it in the same way, though only provisionally, for he remarks, "The organism, whatever it is, must wait further elucidation by materials not yet extracted from the rocks."

Finally, about four years ago, Mr. B. N. Peach, of the Geological Survey of Scotland, found specimens of *Piloceras* at the typical locality, Durness, Sutherlandshire, in which both septa and siphuncle

[1] The substance of this paper was read before the British Association at Manchester, in September last.

[2] Quart. Journ. Geol. Soc. vol. xv. p. 376.

[3] Canadian Naturalist and Geologist, vol. v. p. 171.

[4] Canadian Naturalist, new ser. vol. x. No. 1.

[5] Bull. Amer. Mus. Nat. Hist. vol. i. No. 8, p. 323, pl. xxviii. New York, 1886.

[6] Syst. Sil. de la Bohême, vol. ii. Texte, v. 1877, p. 905.

[7] British Foss. Cephalopoda, pt. i. p. 186.

were preserved, though in a very imperfect condition. These specimens have been very kindly entrusted to me for description by Mr. H. H. Howell, Director of the Geological Survey of Scotland.

They consist of a large number of the detached siphuncles of *Piloceras*, belonging most probably to more than one species. Many of them exhibit more or less distinct traces of the attachment of the septa in the form of encircling ridges, which give them a ringed appearance.

Fig. 1.

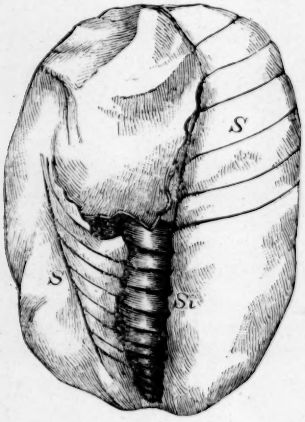

Fig. 1.—*Piloceras invaginatum*?, Salter; *S*, *S*, remains of septa; *Si*, siphuncle, a little restored in the lower part, with ridges marking the attachment of the septa. (One-half natural size).

One of them shows the siphuncle in its natural position (Fig. 1). This is probably the *Piloceras invaginatum* of Salter. The septa must have been extremely thin and fragile, as in most cases they have been broken away from the siphuncle, which is usually found completely detached from them.

In the specimen I have figured the septa appear as delicate lines upon the weathered surface of the rock. They are from $1\frac{1}{2}$ to $3\frac{1}{2}$ lines distant from each other, measuring them from the narrower to the broader end of the siphuncle. The latter is apparently marginal, as in *P. explanator*, Whitf. The exact rate of tapering of the shell cannot be ascertained, owing to the absence of the shell-wall on one side of the specimen, but it may be assumed to have been high.

Another example, showing obscure traces of the septa in contact with the siphuncle, is most probably the small species referred to by Salter in his paper above mentioned, but it is too imperfect to characterize.

Many of the detached siphuncles in Mr. Peach's collection differ from each other in their rate of tapering, and distance of septa (estimated by the distance of their encircling ridges); but I do not feel justified in creating another species out of such imperfect material. The smallest siphuncle in the collection measures 8 lines

in length and 4 lines in its greatest diameter: the largest $4\frac{1}{2}$ inches in length, and $1\frac{3}{4}$ in its greatest diameter. Neither of the specimens measured are perfect. The walls of the siphuncles are usually composed of chalcedony of a minutely concretionary structure.[1]

In comparing the structure of *Piloceras* with that of other Cephalopods, we are at once reminded of *Endoceras*, and the resemblance between these two forms did not escape Salter's experienced eye. In both genera the siphuncle is very large in proportion to the shell, and in both it is furnished with a series of conical or funnel-shaped sheaths, which apparently communicate with one another by means of a small central tube, the "endosiphon" of Hyatt (Figs. 2, 3). This tube is regarded by Hyatt as analogous to that which has long been known in *Actinoceras*, and science is indebted to that able observer for its discovery in *Endoceras*.[2]

FIG. 2.

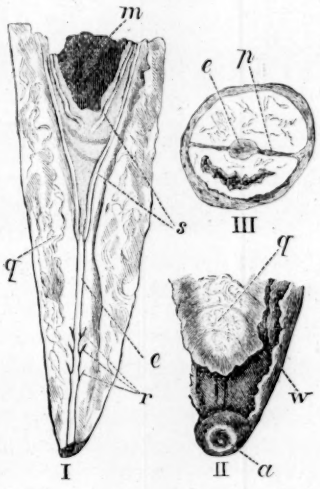

FIG. 3.

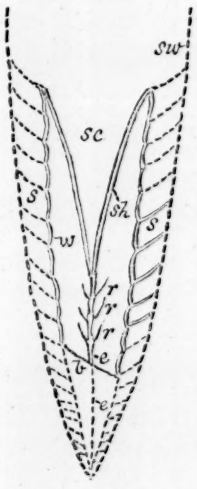

FIG. 2.—I. Section of siphuncle of *Piloceras*, sp., showing two of the funnel-shaped sheaths, *s*; *e*, the endosiphon, with *r*, remains of former sheaths?; *m*, matrix filling what remains of the cavity of the siphuncle; *q*, quartz infilling. II. Posterior extremity of another siphuncle much eroded, but showing an aperture, *a*, at the apex by which the endosiphon may have communicated with the initial chamber; *w*, wall of the siphuncle, and *q*, quartz forming the infilling between this and one of the sheaths. III. Transverse section of another siphuncle showing in the centre the endosiphon *e*, and what appears to be a partition *p*, representing perhaps the septum or "central shelly plate" of Dawson. (All the figures are of natural size.)

FIG. 3.—Vertical section of an imperfect siphuncle, with a few of the septa attached, of *Piloceras amplum*, Dawson, cut in the direction of the shorter diameter of the shell, which was of an elliptical form, judging by that of the siphuncle. *s w*, shell-wall; *s c*, siphuncular cavity; *s h*, sheath; *w*, internal wall of siphuncle; *s*, *s*, septa; *b*, broken extremity of siphuncle; *r* and *e*, same as in Fig. 2. The dotted lines are restorations. (Slightly reduced from Dawson's figure, which is itself a little smaller than the original specimen.)

[1] This form of chalcedony used to be called beekite, but it differs so slightly in composition from ordinary chalcedony that that name is no longer employed for it by mineralogists.

[2] Proc. Boston Soc. Nat. Hist. vol. xxii. April 4, 1883, p. 261.

Professor Hyatt, whose conclusions regarding the present genus are based upon Principal Dawson's paper, explains the origin of the sheaths in *Piloceras* to be due to the widening of what he terms the "fleshy siphuncle" near the body-chamber. The sheaths lie somewhat loosely in the siphuncle, and they are supposed by Dawson, upon the evidence of the specimen described by him (Fig. 3), to have existed only temporarily, and to have been successively absorbed, the last one only becoming completely calcified. In the Durness specimens, however, it is not an uncommon thing to find two or three of the sheaths preserved, their walls standing out in relief from the surrounding matrix, which has been removed by weathering.

A series of short, upwardly projecting lines are observed to spring from the sides of the endosiphon (Figs. 2 and 3), where it is slightly swollen. These lines are conjectured by Dawson to be the remains of the membranous or fleshy sheaths which have become absorbed, as suggested by Hyatt. The close correspondence of these structures in the Scotch and Canadian species is very apparent in Figs. 2 and 3. It is also noticeable that above the sheath whose apex is perforated by the endosiphon there is another one, in a somewhat shrunken condition; this appears also to be perforated, presumably for the passage of the endosiphon, if indeed that organ extended beyond the apex of the larger sheath below, but of this I have no proof, as no vestige of it can be seen above where it is figured. There is every reason to suppose, though I am not able to demonstrate the fact, that the endosiphon opened into the initial chamber, or at least into one of the earlier of the septal chambers, since in all specimens in which the apical extremity of the siphuncle is preserved, it is found to be perforated.

It should be mentioned that Principal Dawson in his description of *P. amplum* refers to the endosiphon as a "vertical partition" crossing the lower part of the siphuncle; but Hyatt, recognizing its tubular character in the figure, interpreted it in the manner already described. Nevertheless there seems to have been an internal septum extending upwards from the lower part of the siphuncle, between the wall of the latter and that of the sheath into which the endosiphon opens. This septum shows itself in some transverse sections of the siphuncle in the manner indicated at *p*, Fig. 2, III., and it can be traced for some distance upwards in the vertical section of this and of other specimens. I am unable, however, to give any satisfactory account of it, owing to its imperfect condition. I venture to think that Sir William Dawson, seeing this septum at the broken end of his specimen (Fig. 3, *b*), concluded that the endosiphon (*e*, *e*) above it was its upward continuation.

As regards the infilling of the siphuncle in *Piloceras*, it seems obvious that the space between the inner wall of the siphuncle and the first permanent sheath was not originally solid, because it is not filled with the matrix, but either with calcareous, or dolomitic, or siliceous matter, introduced by infiltration. Something was therefore required to give support to the sheaths, and this was supplied, in part at least, by the endosiphon, and perhaps also by the "septum" above mentioned.

Whatever the functions of the endosiphon may have been, I do not imagine that it played such an important part in the vital economy of the animal as did the same organ in *Actinoceras*. The large endosiphon in the latter gave off tubuli which passed through the membranous walls of the siphuncle by means of foramina.[1] Sir Richard Owen conjectured that these tubuli served "for the passage of blood-vessels to the lining membrane of the air-chambers."[2] At any rate, a vital connection was maintained between the endosiphon and each of the septal-chambers in *Actinoceras*, which was wanting in *Piloceras*.

The genus *Piloceras* may now be thus redefined:—

Shell more or less broadly conical; slightly curved; somewhat compressed laterally; elliptical in section. Septa rather numerous. Siphuncle formed by the prolongation and conjunction of the necks[3] of the septa; marginal; very large; partaking of the curvature of the shell; provided internally with one or more conical, or funnel-shaped sheaths, which are united at the top with its margin. These sheaths apparently communicated with one another by means of the endosiphon, which perforates the apex of the siphuncle. The endosiphon originated in one of the earlier of the septal-chambers, if not in the initial chamber itself.[4]

Five species of *Piloceras* have now been described, viz:—

P. invaginatum, Salter.
P. Canadense, Billings.
P. Wortheni, Billings.
P. amplum, Dawson.
P. explanator, Whitfield.

Thus, nearly all the structures in the siphuncle and some of those of the chambered portion of the shell of *Piloceras* described by Dawson and Hyatt are demonstrable in the splendid series of specimens brought together by Mr. Peach.

The great desideratum now is to obtain a specimen which will disclose the connection between the apex of the siphuncle and the chambered part of the shell. For this purpose a tolerably perfect specimen would be required. Perhaps some of the material so ably dealt with by Professor Whitfield may supply the want? One can scarcely expect to find sufficiently perfect specimens in the Durness rocks.

From a geological point of view *Piloceras* is interesting on account of its association in Scotland and in eastern North America with a little group of fossils in which several species appear to be common to both countries.

[1] These are beautifully preserved in many examples of *Actinoceras* in the British Museum (Nat. Hist.).

[2] Palæontology, 2nd ed. 1861, p. 102. See also L. Saemann, Ueber die Nautiliden, Palæontographica, Band iii. 1845, p. 121, Tab. xviii.

[3] Called "funnels" by Prof. Hyatt. "Siphonalduten" of the Germans; "goulots" of the French.

[4] Hyatt in his definition of *Piloceras* (loc. cit. p. 266) states that it is "often annulated," but this is evidently an inadvertence, because the outer shell was unknown when he wrote, and remained so until the specimens described by Prof. Whitfield saw the light, and these showed only "a few transverse wrinkles of growth." He probably had in his mind the detached siphuncles, which have an annulated appearance caused by the adherent remains of the septa.

Salter enumerates amongst others the following American species in the Durness Limestone; some of which, however, are too imperfect for accurate identification:—

Orthis striatula, Emmons [non Schlotheim].
Ophileta compacta, Salter.
Maclurea matutina ? Hall.
Orthoceras arcuoliratum, Hall.
——— *undulostriatum*, Hall.
——— *vertebrale* ? Hall [very doubtful].

In addition to these, there are among the fossils I received from the Geological Survey of Scotland, specimens of *Endoceras* in a very fragmentary condition, but resembling certain small (?) species with very closely approximate septa, described and figured by Billings from the Calciferous group of Canada.[1]

A *Cyrtoceras*, very probably the *Oncoceras* ? referred to by Salter, is also in a condition unfit for determination.

Though the Durness fossils are by no means well preserved, yet it can hardly be disputed that their general facies, as Salter affirmed, is American rather than European. The testimony of the fossils, so far as it goes, is supported by that of the rocks, for we learn from Mr. Peach[2] that in the order of succession of the beds in the North-west Highlands of Scotland an almost exact counterpart is presented of the strata "exposed along the axis of older Palæozoic rocks, stretching from Canada through the Eastern States of North America."

"In the latter region," continues Mr. Peach, "the Silurian strata of Sutherlandshire are represented by (1) the Potsdam Sandstone, always described as being vertically piped by *Scolithus*, like the "pipe-rock"; (2) the Calciferous group; and (3) part of the Trenton Limestone.

He further argues, that the beds in these widely-separated areas, though probably not contemporaneous, were homotaxial, and he supposes that the species migrated from one province to the other "along some old shore-line or shallow sea," some barrier separating them from Wales and Central Europe.

IV.—Woodwardian Museum Notes: on some Anglesey Dykes. II.

By Alfred Harker, M.A., F.G.S.,
Fellow of St. John's College.

In the northern half of Anglesey occur several intrusions of dark hornblendic rocks, some specimens of which were placed by Henslow in the collection made by him for the Woodwardian Museum. These rocks present a type unusual in Britain, and show some peculiarities which are of considerable interest.

A few years ago Professor Bonney found on the south-west coast of the island some boulders of a rock which he described[3] under the

[1] Canadian Naturalist, 1859, vol. iv. p. 361.
[2] Presidential Address before the Royal Physical Society of Edinburgh, Nov. 1885.
[3] Q. J. G. S. vol. xxxvii. p. 137, 1881: vol. xxxix. p. 254, 1883: vol. xli. p. 515, 1885. See also Teall, "British Petrography," pp. 81, 82; plates iv. and vi. 1886.

name of Hornblende-picrite. It was subsequently pointed out by Professor Hughes that the probable source of these rocks was to be found in certain intrusive masses near Llanerchymedd, and indeed such boulders are scattered about rather abundantly in that neighbourhood and to the south-west. The rock in question seems, however, to be the common type of the larger eruptive masses in the north of Anglesey, and brief notes on slides cut from selected specimens taken in place may be found not unprofitable. The rocks were noticed and megascopically described in Henslow's Memoir.[1]

There are three localities in each of which similar varieties occur. The first lies to the north and north-east of the town of Llanerchymedd, where the map of the Geological Survey shows nine intrusions. These masses, not properly dykes, have an oval or elongated form, with lengths of from 200 yards to three-quarters of a mile, their long axes running generally with the strike of the adjacent strata. These beds, Arenig according to Professor Hughes,[2] are baked at the junction, but not extensively altered. On Henslow's map no attempt is made to separate the several patches, which are marked as one area of "greenstone." I have collected specimens from the six masses lying between Rhodogeidio and Llandyfrydog, but am not able to state whether the three patches to the north of the latter place are of similar characters.

A large irregularly-shaped mass appears on the western slope of Llaneilian Mountain, in the north-eastern corner of Anglesey. This has been mentioned by Professor Hughes and examined microscopically by Professor Bonney. It too pierces rocks probably of Arenig age, as well as the debatable Amlwch series. Our specimens are from Pengorphwysfa.

The third area is situated to the east of Llanbabo, among the alluvial deposits of the River Alaw. The exposures here are, according to Henslow, "not well exhibited," and they have escaped the notice of the Survey; but the locality is verified by Professor Hughes, who obtained a similar rock from south-west of Glas-grug.

Rocks having many points in common with these occur as parts of some large dykes in Holyhead Island; but they will be more conveniently considered apart, and our present description will apply only to the three groups of intrusive masses mentioned above. The specimens are selected as follows:—

I. Hafod-in-in dyke (A 130, 131);
Rhodogeidio dyke (A 132);
Llys Einion dyke (A 86, 91, 94, 134, and Hughes Coll. 33);
Maen Chwynt dyke, probably (Sedg. Coll. 37);
Llandyfrydog dyke (Henslow [695]);

II. Llaneilian Mountain intrusive mass (A 35, 37, and Hughes Coll. two slides), all from Pengorphwysfa near Amlwch; also Henslow [715];

III. Dykes or masses east of Llanbabo (Henslow [711, 712]).

Besides these, a large number of hand-specimens from all the localities have been examined.

[1] Trans. Phil. Soc. Camb. vol. i. 1822. [2] Q. J. G. S. vol. xxxviii. p. 26, 1882.

The constituent minerals of these rocks are apatite, ilmenite, pyrites, magnetite, olivine, felspar, augite, hornblende, and biotite; besides leucoxene, serpentine, calcite, quartz, chlorite, epidote, and other secondary products.

Apatite is often abundant in slender prisms, and seems to be always the earliest formed constituent.

Iron-ores are almost always among the original minerals, and sometimes magnetite and ilmenite are recognizable in the same slide. Ilmenite when best developed shows in skeletons of intersecting rods choked with grey leucoxene; in other places the presence of a titaniferous mineral can only be inferred from these cloudy grey masses. Magnetite sometimes forms rods, but more usually imperfect cubes. There is also secondary granular magnetite resulting from the alteration of the iron-bearing silicates. In some of the original grains a scarcely perceptible brown translucency may indicate picotite.

Olivine is rarely abundant, and for the most part not detected. Occasionally rounded and oblong patches of serpentine show the characteristic mesh-structure; but the bulk of this substance met with in the slides can be clearly traced to the decomposition of pyroxene and amphibole minerals, and is usually mixed with chlorite. The rocks east of Llanbabo, however, show plenty of olivine.

Felspar of the lime-soda series seems to have been a universal constituent, and locally abundant. In most of the slides this mineral is replaced by calcite, chlorite, and quartz. Where the felspar is fresh enough to exhibit its original characters, it seems from its low extinction-angles to be never a very basic variety: it may be referred, if this test is trustworthy, to andesine and oligoclase. Twin-lamellation on the albite-law is almost always seen, but the pericline twinning rarely. The felspar is usually later than the ilmenite, and earlier than the augite and hornblende, which it penetrates; but in some slides from Llys Einion the felspar partly penetrates and partly moulds the hornblende.

Augite is not always present, but it is probable that this mineral has been essential in all these rocks, and has been in great part replaced by hornblende. In some slides from the Llys Einion and Llanbabo dykes the process of conversion can be traced. The two minerals have the orthopinacoids and the clinopinacoids parallel: they are most intimately associated, with an extremely irregular line of division, and the augite often remains as a core surrounded by brown hornblende.

Hornblende is the most abundant mineral in these rocks, and occurs in several distinct varieties. It is the prevalence of one or other of these varieties, as much as any essential diversity of constitution in the rocks, that gives rise to the difference of aspect observable in hand-specimens.

Original hornblende is found in well-formed crystals, usually from one-eighth to half an inch in length. The terminal planes are probably in most cases the usual (011) and ($\bar{1}$01), but the basal plane also occurs (001), and a very oblique one which may be ($\bar{2}$01).

The cross-section always shows the prism form (110) well developed, often truncated by the clinopinacoid (010), and sometimes the orthopinacoid (100). Twinning on the usual law is common. The prismatic cleavages are well-developed, and rarely the clinopinacoidal cleavage is nearly as well marked. The colour is usually brown, with strong pleochroism, vibrations parallel to the axes of elasticity giving: γ, deep chestnut brown; β, a less deep brown; α, a pale brown. The absorption is then $\gamma > \beta >> \alpha$; more rarely it is $\gamma = \beta >> \alpha$. Sometimes, however, this original hornblende is brownish-green, the vibrations parallel to the γ-axis giving a pale grass-green, and perpendicular to it a very pale brown. The larger crystals occasionally present a mode of alteration different from the ordinary chloritic and serpentinous changes, and consisting sometimes of a brown coloration, sometimes a decoloration and decomposition into a granular substance. These alterations affect the hornblende along certain planes, which are not parallel to the prismatic cleavage, but to the clinopinacoid, and are perhaps to be regarded as "solution-planes" (*Lösungsflächen*).

Another kind of hornblende, probably also original in the usual sense, is often present in the dykes to the north of Llanerchymedd. A cross-section of a brown hornblende crystal is seen, showing the prism and clinopinacoid faces, but upon the latter a later accretion of green hornblende-substance, in crystalline continuity with the brown, has reduced or entirely built over the clinopinacoids, extending the prism-planes at their expense. From its relation to surrounding minerals and from its always presenting definite crystal boundaries, this later growth of green hornblende seems to have originated before the final consolidation of the rock.

Next comes the hornblende resulting from the alteration of original augite. The "paramorphic" origin of hornblende from pyroxenic minerals has received so much notice in recent years, that there is no need to enlarge upon it here, further than to remark that the term "paramorphism" is strictly applicable only when the two minerals yield identical analyses, which is probably an unusual case. In the present instance it is most likely that some chemical as well as physical change is involved. The hornblende thus produced is brown, compact, and well-cleaved: in fact a study of the Anglesey dykes, as well as rocks from several localities in Carnarvonshire, bears out the conclusion of Lossen and others, that neither colour nor structure affords any reliable criterion for discriminating between original hornblende and that resulting from the amphibolisation of augite. It is possible that some of the hornblende may be derived from a rhombic pyroxene, and indeed the slides from the rocks east of Llanbabo have a mineral resembling altered enstatite. Professor Bonney has noticed the same in the Llys Einion dyke and boulders.

Some slides (*e.g.* from the Hafod-in-in dyke) contain a considerable quantity of a rather pale, dull, brownish-green or greenish-brown hornblende without crystal boundaries. Compared with the foregoing varieties, it is seen to be less clear and less strongly coloured, to give lower polarisation-tints, and to have its cleavage-

traces often less pronounced. It is later than the original brown hornblende, which it includes. It also includes augite, without any definite crystallographic relation to it, and so is probably not 'paramorphic.' On the whole, it seems likely that this dull-coloured hornblende is a secondary growth posterior in date to the consolidation of the rock, though this cannot be regarded with certainty, as in the following case.

Lastly, we have hornblende, sometimes green, but more commonly colourless, forming a sharply-defined border to original hornblende crystals, and filling the interstices between them. A study of the slides leaves no doubt that this new growth of hornblende-substance has taken place subsequently to the consolidation of the rock. In some cases it can be verified that the new hornblende extends into the space formerly occupied by felspar crystals. Again, the interspace between two or three original or paramorphic hornblendes is found to be filled by colourless substance, which between crossed Nicols breaks up into distinct portions in crystalline continuity with the several adjacent crystals. This is exactly analogous to the cement of secondary quartz observed by Dr. Sorby and others between the grains of certain quartzites. Sometimes a well-bounded original crystal has a sharply-defined border of greener hornblende, and outside this a margin of colourless hornblende-substance with ragged outline abutting upon patches of calcite dust, etc., which probably represent destroyed felspar. In such a case the double border is all in crystalline continuity with the original crystal. The secondary hornblende here described gives rather higher polarisation-tints and a slightly wider extinction angle than the other varieties of the mineral.

Mr. Van Hise, who was the first to notice the "secondary enlargement of hornblende fragments" in conglomerates, has recently described[1] a like phenomenon in altered diabases from Michigan and Wisconsin, and he cites similar results arrived at by Becke[2] in 1883. I am not aware that this secondary growth of hornblende on the margins of pre-existing crystals has been recognized in British rocks, although Prof. Bonney, referring to the rocks now under discussion, has remarked on the sudden transition from dark brown to almost colourless hornblende, and has figured a very characteristic case in a similar rock from Little Knott in Cumberland.[3] The Rhodogeidio and Llys Einion dykes furnish the best examples.

The only remaining mineral that calls for special notice is the brown mica, which has been mentioned above as biotite, although its characters are not easy to make out very definitely. It is not abundant except in some specimens from Llandyfrydog, which have to the eye almost a lamprophyric aspect. In his specimen [695] especially Henslow remarks the presence of "small shining plates, apparently diallage." These are the flakes of mica, and their peculiar lustre is explained on examination under the microscope.

[1] Amer. Journ. Sci. May, 1887, 3rd ser. vol. xxxiii. p. 385.
[2] Tscherm. Min. u. Petr. Mitth. vol. v. part ii. 1883.
[3] Q. G. G. S. vol. xli. plate xvi. fig. 2, 1885.

The slide appears at the first glance totally unlike all the others, showing only numerous flakes of mica in a confused mass of decomposition products, without any trace of augite, olivine or hornblende. The mica is less strongly coloured and less pronouncedly dichroic than is usual in biotite, except in the bleached mineral often met with in the lamprophyres and some peridotites. It gives, however, a moderately deep or rather light brown for vibrations parallel to the cleavage-traces, and a paler brown in the direction at right angles to this. The extinctions are sensibly parallel and perpendicular to the traces, and a cleavage-flake is dark between crossed Nicols. The plates are split into thin lamellæ separated by lenticular grains and layers of a colourless, doubly refracting mineral. The interposition of calcite lenses between the foliæ of biotite has been noticed by Zirkel, Hussak, and Williams, but here the mineral is not calcite. Each lenticular grain consists of portions differently oriented, and there is sometimes a radial fibrous appearance suggestive of a zeolitic mineral. The mica includes also a large quantity of granular magnetite. A slide [711] from the Llanbabo mass contains precisely similar flakes of mica, though in much less quantity, and the mineral appears to be closely connected with the brown hornblende, as if resulting from its alteration. This slide probably shows the beginning of a process of which the Llandyfrydog specimen represents the final stage. The secondary production of biotite in place of hornblende is seen also in the Pen-y-rhiwiau and Penarfynydd rocks mentioned below, and in some other Welsh rocks, such as the syenite of Llanfaglen near Carnarvon.

The structural variations of each dyke have not been studied in detail. As Henslow and Professor Hughes have pointed out, the megascopic characters often change largely in a very short distance, though the microscope shows that these variations do not always import any considerable difference in constitution. The more felspathic type of rock sometimes occurs as segregation-veins in the darker and more hornblendic. The dykes grow rather finer-grained at the immediate margin, and these portions are more susceptible to destructive weathering action than the coarser rock. A slide (A 134) from Llys Einion, close to the junction with the shales, shows advanced decomposition; but besides the calcite, 'viridite,' etc., there remains an abundance of felspar in good crystals, and partly bleached brown hornblende in crystals and ophitic plates, the latter bordered by colourless fringes of the usual secondary growth.

The coarse black type of rock, with its cement of secondary hornblende, is very durable, and, as has been remarked, the erratics are mainly of this variety. The dykes themselves form prominent features in the country, which doubtless led Henslow to map the whole district north of Llanerchymedd as consisting of these rocks. The smaller dolerite dykes of southern Anglesey, on the other hand, make but little show at the surface, and are difficult to find; a fact indicated on the Survey Map, where the greater part of the dykes marked are on the sea-shore.

The affinities of the rocks described above have been discussed by Prof. Bonney, who points out their close resemblance to that of Pen-y-rhiwiau near Clynnog-fawr, Carnarvonshire, and the so-called Diorite of Little Knott in Cumberland. With the latter I am not acquainted, but a number of slides cut from selected specimens of the Pen-y-rhiwiau mass show the closest resemblance to these Anglesey dykes, especially those of Rhodogeidio, Llys Einion and Hafod-in-in. There are the same minerals associated in the same manner,[1] the amphibolisation of the augite, the secondary marginal growth of colourless amphibole, and the apparent conversion of the brown hornblende into biotite being all well exhibited. There is more olivine than in the Anglesey 'dykes,' although this constituent is variable in amount, and a few other differences are to be noted; but the rocks may well be classed together. Bearing in mind the comparatively small quantity of olivine found, the constant presence of felspar, and that not of a basic variety, the common occurrence of original iron-ores, and the general structure of the rocks, they seem to find their most natural place among the olivine-bearing hornblende-diabases, rather than with rocks of ultrabasic type.

The mode of occurrence of these masses is different from that of the beautiful hornblende-picrite of Penarfynydd, which forms a massive bank 200 or 300 feet in thickness, and of very uniform character. It is worthy of note that the intrusions of Llys Einion and Llaneilian Mountain, as well as Penarfynydd, occur in Arenig strata, and the slates at Pen-y-rhiwiau are referred to the same age: I do not know with what degree of probability the Skiddaw slates of Little Knott can be assigned to the Arenig also.

V.—Two New French Meteorites.

Preliminary Notice by James R. Gregory.

TWO Meteorites from France have recently come into my possession from a private source, one of which, though not of a recent fall (1836), has neither been described nor chemically examined, and which I now briefly bring to notice, it being of a most rare type. The other is of a much more recent fall (1875), and is of a much more ordinary character, being similar to many other meteorites of the same class; this stone also appears not to have been described, nor has any notice of it been published. It is somewhat a remarkable coincidence that these two stones should have fallen in the same Department, although at such widely different dates, and from the data and notes I have received from careful inquiries, I now bring forward the following details of these two aerolites.

I. Aubres, Commune of the Canton of Nyons (Drôme), France.

This meteoric stone fell on September 14, 1836, at 3 p.m., in calm weather and blue sky, at Aubres, Commune of the Canton of Nyons, in the department of Drôme, France. It fell on a hard and pebbly

[1] The resemblance even extends to the 'solution-planes' in the brown hornblende, parallel to the clinopinacoid (010). The slides from Pen-y-rhiwiau, however, contain an abundance of pale grass-green actinolite in blades and fan-shaped bundles.

road, near to a tree under which a shepherd named Favier had taken refuge. This man hearing—to use his own words—"something snore which came from the heavens," observed the fall and found the stone, which had forced itself in spite of the hardness of the road into the soil, it is not stated to what depth—probably no great distance, owing to the fragile character of the meteorite; he afterwards drew it out with his stick, the end of which was stated to have been burnt by the heat. This is probably a fancy, as the nature of the stone would preclude the idea of any great heat being present, it being essentially a stony meteorite, containing apparently no free nickel-iron, and consequently less likely to be hot, or so hot as meteorites containing much metallic particles, they being better conductors of heat. The man states that having allowed it to cool he took it to his master's house, where it was broken to find out what was inside, and then seeing it was "a stone like other stones," it was thrown upon a shelf and forgotten. In 1845 the Pasteur Muston of Bordeaux, who was interested in mineralogy, happening to hear of the circumstances of the fall, went and examined it, afterwards purchasing it, and who had retained it, till it came into my possession. No other stone was found, or believed to have fallen, nor has any public notice appeared of the circumstances attending its fall. It was found by simple peasants who saw nothing very wonderful in it.

This very interesting stone at present weighs 567 grammes, though probably at the time of its fall it must have weighed about 800 grammes, a portion being broken off by the shepherd who secured it, and which is probably lost. It is of an extremely fragile nature and more like that very rare type the Bustee meteorite. It has a highly crystalline structure, exhibiting broad cleavages of an almost white mineral, it has also a very brecciated appearance, but does not seem to contain any of the peculiar mineral named osbornite by Prof. Maskelyne, who first described this mineral in the beforenamed stone of Bustee; it contains certain small brown patches which may prove to be osbornite on careful examination. The crust is extremely thin, of a pale brown colour, and somewhat vitreous and sufficiently translucent to show the brecciated structure of the stone within, in this respect it also resembles the Bustee meteorite; some parts of this crust exhibit a slight iridescence. In form it is somewhat oval, rather flattish, and pitted with the frequent pittings characteristic of many meteorites as well as meteoric irons.

II. Commune of Mornans (Drôme), France.

This meteorite fell in September, 1875, in the Commune of Mornans, Canton of Bordeaux, Department of Drôme, France, the exact date apparently is not known; it is said to have fallen in calm clear weather, and followed an explosion which was preceded by a gust of wind, and gave during its fall a harmonious sound compared to that of an organ; many minute details seem to have either been forgotten or were not observed at the time of the fall.

The stone probably weighed about 1300 grammes, and when it

came into my possession weighed 1170 grammes. In form it is rather rectangular, with rounded angles and prominences, being thicker in the middle of the stone. The interior is of a fine-grained granular structure of a bluish-grey colour, and contains several of the veins or faults like the meteorite of Chateau Renard and others, and belongs to the chondritic class of meteorites; it contains a comparatively small amount of iron, which is evenly disseminated throughout the mass, the crust is of a moderate thickness and of a dull black colour; about one-half of which is covered with a brownish stain, probably where it rested on the soil, a character frequently observed in other meteorites. A single stone apparently only fell, at least no others were found. The fragment broken off was said to be for the purpose of analysis, but the result is not known, as no public notice has been made of this fall.

VI.—Notes on Pliocene Beds.

By Robert George Bell, F.G.S.

FOR some years past the Upper Tertiaries of England have not received such a liberal share of attention as was bestowed on them at one time by the older geologists, probably in part because of the impression unwittingly encouraged by some of the authorities in science, that little original work in the way of discovery can now be done in connection with the organic contents of the Upper Tertiary deposits, the number of species already recorded being very large.

Other considerations, such as the comparative shortness and insignificance (geologically considered) of the period of time during which these deposits were forming, have also doubtless tended to divert the attention of the younger students of geology to the more difficult and less known faunas in older formations.

And yet the termination of the discovery of new species would seem to be as far off as ever. Very little is actually known of the fossil forms of many of the lower classes of organisms; indeed, excepting in the Mollusca, the information that has at present been published is extremely meagre, our knowledge of the Annelids, Echinoderms, Polyzoa, and many other groups of the Invertebrata, in which the Pliocenes of Britain are very rich, is in fact astonishingly behind that which has been attained as regards Mollusks and Vertebrates.

Independent of fresh discoveries, there is a line of research which may with advantage be followed by the palæontologist dealing with material already identified, and about which much is known. He may seek to trace out the life history in time and space of a species or group of species, which, having appeared in some antecedent period, has lived on to our own time. For such purpose the present generation possesses many advantages, the numerous recent deep-sea explorations having revealed facts respecting geographical and bathymetrical distribution which help to elucidate the condition of the Tertiary seas, and thus to enlarge our acquaintance with the zoological history of many fossil forms.

Research on similar lines was advocated some years ago by the late Edward Forbes to the zoologists of his day. He remarks that "to get at the causes of such phenomena (the distribution of species), we must trace the history of the species backward in time and inquire into its connection with the history of geological change." It is evident that such a course of investigation as that suggested by Forbes must prove to be equally beneficial to palæontological students, and its wisdom has been often manifested of late years, during which experience has shown how dependent each line of study is upon the other.

The earliest indication of the Pliocene period in Britain seems to be the strongly ferruginous deposit at Lenham near Maidstone, occupying the so-called pot-holes of the Upper Chalk surface, and spreading over a considerable extent of the North Downs; at this place the impressions of shells in this hard rock are plentiful, and so far as present observation goes are of Pliocene forms. The locality has never been thoroughly examined, and would well repay patient exploration. The latest list of the species, which, however, is not exhaustive, is in a communication by Mr. Clement Reid, F.G.S., to "Nature" (No. 876, August 12th, 1886), and contains some which have not yet been found in our Crags. The age of this Lenham bed is now generally regarded as that of the similar Diestien deposit in Belgium.

Mr. Reid holds that this deposit is contemporaneous with our Coralline Crag. However that may be, the writer must strongly demur to the association of either of these deposits with those found in the well-sinkings near Utrecht, the fossils of which are so well identified and delineated by Dr. J. Lorié, in the paper referred to by Mr. Reid.

The high northern character of many of the Mollusca found in these beds is unmistakeable, and is closely correspondent with that of the fauna of the upper deposits of the Red (Butley) Crag. It is significant that no such Arctic forms as several of those mentioned by Dr. Lorié have ever occurred either in the Lenham or Coralline beds.

The fauna of these earlier deposits indicate a warmer temperature and a nearer relation to Miocene times than that possessed by the Red Crag. The *Cassidarias*, *Pyrulas*, *Volutes*, and other shells, *Fusus alveolatus* and *F. consociale*, for instance, all of semi-tropical character, occur in certain zones of the earlier Crag in some profusion, and generally in perfect condition; indeed, where the matrix is dry, they may compare favourably with the French Tertiary shells. In the later Crags the southern species thin out and fast disappear as we rise higher in the series, and in the case of species which are not uncommon to both, *e.g. Voluta Lamberti*, the condition is rarely perfect, and the fine sculpture observable in the Coralline Crag shells is always absent; even those shells which undoubtedly lived in both formations, such as *Buccinopsis Dalei*, have materially altered in shape and size after the advent of the Red Crag, and appear in greatly increased numbers.

The changes both in diversity of climate and of life have doubtless

been very great in the East Anglian area during the Pliocene period; the species quoted above are a few examples among many which exhibit these alterations. Do not such facts imply that a much longer time than is generally allowed, is necessary to account for the variation and extinction of species, which occurred during the formation of the Crags?

At Walton-on-the-Naze, the Red Crag is shown (as the late Mr. Searles Wood always insisted) in its earliest and purest condition; it is the most instructive section at present visible, and contains by far the largest number of species, especially of Mollusca, of which about 235 have been recorded up to the present time; yet many of the genera of the older Crag, particularly those of southern habit, are absent, and others exist only in a dilapidated or fragmentary state.

An examination of the deposit shows that it was formed in a shallow depression of the London Clay, in the central and deepest part the Crag beds being almost horizontal and undisturbed. Here a number of *Pectunculi* may be found, with their valves united, and in the position in which they lived and died. Just above this bed the large Almond Whelk, *Fusus antiquus*, makes its first appearance in geological history, and so far as evidence is concerned this seems to have been its birth-place; it comes in as it were with a rush (as at a much later date did *Tellina Balthica*), the deposit at this spot being full of them in the finest and most perfect condition.

The appearance of this shell in our Pliocenes may be taken as one of the best indications of the great change of climatic conditions which had occurred since the close of the Coralline Crag; it may be seen in plenty in the Red Crag beds overlying the Coralline at Sutton (the best and almost only instance where the superposition can be seen); but it has never been observed in an earlier deposit, either here or on the Continent.

Another striking evidence of change of condition in the East Anglian area is that this shell is the first and best representative of a family or section (Neptunea) of the old Linnæan genus *Murex*, which is almost exclusively confined to the Boreal and Arctic regions of the world. Not only this species, but the whole of this particular section (if the doubtful subgenus *Sipho* is excepted) had, so far as has been ascertained, no previous existence to Red Crag times, since which period it has continued with undiminished vitality, and in recent seas it is as plentiful in suitable places as formerly, and exhibits still more variety than in the limited Crag area.

The sculpture of the earliest form agrees in its fine striation with that almost universal with these shells round the coasts of Great Britain, and more particularly with those on the sandy flats round the mouth of the Thames. Only in St. George's Channel off the Irish coast does the carinated variety occur in any number. Several other northern forms of Mollusca have been found here at various times, some quite recently, as *Fusus Islandicus* (Chemnitz), and it would seem to point to the existence there of one of those old boreal outliers mentioned by Edward Forbes as among the indications of a former glacial climate.

The shells of *Fusus antiquus* found in the lower beds of the deposit at Walton are invariably sinistral; but in the middle zones of the Red Crag about Sutton the dextral shell occurs plentifully, and both forms are often carinated; but in the upper horizon in the neighbourhood of Butley, and in the Norwich Crags, these carinations are more pronounced, and the reversed shells generally fewer. It is here that the Boreal and Arctic Mollusca are most numerous, and that the number and size of shells having southern affinities dwindle into smaller proportions.

The contention of Mr. Searles Wood that this species first appeared in the reversed state, afterwards becoming dextral in the course of time, certainly appears to agree with known facts. In the grey sand at Walton, as in the Belgian equivalents of this zone, no dextral forms have been found, although in the upper *Red* Crag at this section two broken and worn specimens have rewarded a long continued search.

How to account for this important variation of form is more problematical: is it dependent on alteration of climate? Perhaps the gradually cooling condition of the Crag seas was prejudicial to the original state of the shell, the dextral variety may be a hardier form gradually superseding the other, until it has become the rare exception only occasionally found. The cold seas of the Arctic climate certainly possess two Molluscs, *Buccinum deforme*, Midd., and *B. Harpa*, Morch. (*Heliotropis*, Dall.), which are always sinistral, and Middendorf mentions the reversed *F. antiquus* as found in the Polar Sea and Russian Lapland, and Woodward as from the Sea of Ochotsk; but these examples must be extremely rare, and altogether it seems that the sinistral condition of any of the shells of Mollusca, whether that condition be normal or not, is much less frequent in cold than in warm or even temperate seas. In Great Britain it is doubtful whether the reversed *Fusus* has been found living anywhere except in the neighbourhood of the German Ocean, where among many thousands of others an example closely approaching the Walton type is occasionally seen; but in Vigo Bay, in the north of Spain, a small colony still lingers, the late Mr. McAndrew having collected it with a number of other shells of Celtic character. The specimens do not seem to differ materially from other coarsely striated forms, and are certainly identical with those from the Pleistocene deposits of Sicily; but there is no certain authority for its existence in the Mediterranean.

The small reversed form from the Wexford gravels may be mentioned here; it is different from any other known to the writer, being very thick and quite smooth; it is said to be associated with many southern shells. So little, however, is accurately known with regard to the position or contents of the various beds of marine gravels in Ireland, that at present any conclusions must be premature.

The variety of form and sculpture exhibited by this species in the Red Crag is more than equalled by its divergence in modern times. The *Fusi* found in the Northern Hemisphere no doubt present great differences, but in their general characters most of them have a

strong resemblance to one another, and, considering the long lapse of time *Fusus antiquus* has lived, the many geographical positions it has occupied, the different conditions, climatal and otherwise, in which it now exists, is there not reason to conclude that it is the original parent stock from which most of the species now inhabiting the Northern Hemisphere have branched forth?

The New England shell called *Fusus tornatus* by Gould (Inv. Mass. 2nd edit. p. 37) closely resembles some examples collected at Bramerton, near Norwich; it is recognized by him as resembling the Crag fossil; its relation to *Fusus despectus*, L. (which again it is almost impossible to divide from the carinated form of *F. antiquus*) is acknowledged by later authorities, such as Verrill, Sars, and Friele.

In the Red Crag, however, the carinations are seldom, if ever, shown so sharply as in the last-named shell, possibly from abrasion as in the case of most Crag Gasteropods; in their present aspect with their strong coarse carinæ, they nearly resemble the older shells of *F. liratus*, Martyn, a native of Behring Sea. *F. fornicatus* of Linné, which has the carinæ coarse and undulating, has not been met with in the Crag, although sought for diligently by the late Mr. Wood.

On the Pacific Coast of North America *Fusi* are scarce in number, *F. tabulatus* of Vancouver not having much resemblance to our shell; but on the opposite coasts of North-Eastern Asia varieties of the common form occur in the seas of North Japan. The Aleutian promontory and group of islands probably deflecting many of the Arctic Molluscs inhabiting deep water to the Asiatic side, where they are carried south by the main current of water which sets that way.

The fragmentary character of the geological record is very apparent in the Pliocenes of Northern Europe, but their total absence in North America, and our limited knowledge relating to any of these deposits (small in extent as they are) outside the British Islands, imposes great difficulty and consequent imperfection in such life studies as have been attempted above.

VII.—The Dimetian of St. Davids.

By T. Mellard Reade, F.G.S.

HAVING been lately at St. Davids, I made some observations in relation to the Porth-lisky granite or Dimetian of Dr. Hicks, which may be worth recording in the pages of the Geological Magazine.

Perhaps it may be well for me to state that previous to my examination I had no bias whatever in favour of any of the explanations of the geology of St. Davids which have been offered by Hicks, Geikie, or Blake.

With Dr. Hicks's map in hand[1] I examined many of the contacts of the granite with the surrounding rocks, but could see no evidences of any faulting sufficient to justify its title to be recognized as a distinct Archæan formation.

The evidences I did collect, as will be seen in the sequel, tend to

[1] Pre-Cambrian Rocks of Pembrokeshire, Q.J.G.S. vol. xl. p. 560.

show that the rock is not in any sense Archæan, but is post-Cambrian and intrusive.

First, a few words with regard to the nature of the faults required on Dr. Hicks's hypothesis to entitle the granite or granitoidite to be considered the oldest of the Archæan series he has sought to establish at St. Davids.

The bedded rocks surrounding the granite boss have a high dip often approaching the vertical. On the one side to the south and in contact with it lie the admittedly Cambrian rocks, and on the other to the north-west also in contact, the underlying volcanic series or "Pebidian" of Hicks. Now as the "Dimetian" (granite) is in Dr. Hicks's view older than either series, yet occurs between them, it cannot have been placed in its present position by the folding which tilted the Cambrians and volcanics. It must therefore have been pushed through these highly-inclined rocks as a sort of plug, consequently Dr. Hicks in his map has shown the granite cut off from the surrounding rocks by a set of boundary-faults. To establish the existence of such a remarkable phenomenon would require the most complete and reliable evidence—such evidence as I venture to think has not yet been given.

If we consider the throw required in this way to bring the "Dimetian" into its present position, we shall find that it will have to be estimated by thousands of feet. Does any geologist venture to assert that the so-called junction faults represent any such a movement? On the contrary, had such tremendous displacements occurred, I hold that geologists would have universally recognized them, whereas some dispute the very existence of the junction-faults. Unless some one holding Dr. Hicks's view can frame a consistent theory by which the "Dimetian" can be got into its present position without the aid of these great throws, I shall continue to hold this reasoning unassailable.

It may be said that these are mere general considerations that are not conclusive, or at least do not carry conviction to some minds. Let us see if there are evidences of another class which support this contention.

In the much-examined junction of the granite and Cambrian conglomerate on the right bank of the Alan at Porth-clais, of which there is a wood-cut in Dr. Hicks's paper[1] the granite shades off into the conglomerate, here not much more than a coarse grit, in a way to make their separate recognition difficult. The conglomerate in consequence of a reversed dip lies upon the green Cambrian shales or sandstones,[2] which dip under it and the granite to the north at an angle of about 62°.

The conglomerate is seen also above the granite, but probably this is only the junction face disclosed through the granite having been removed from the front of the conglomerate. To explain myself

[1] Q.J.G.S. vol. xl. p. 532.

[2] The rock is very like the grauwackes of Wigtonshire. Hicks calls it greenish sandstone, Geikie green shale; it is of an intermediate constitution, but I adopt the term shale.

fully would require a plan and sectional elevation; but so much has already been laid before the geological public with regard to this particular junction that I refrain from the infliction.

The Cambrian rocks to the south of this junction strike across the harbour of Porth-clais nearly due east and west, and on the left or east bank the granite is directly in contact with the green Cambrian shales. The conglomerate is not to be seen. At a distance of about 30 feet north of this contact, and embedded in the granite, is a vein [1] of green shale about 18 inches across, and another about 10 feet nearer to the contact about 6 inches across. Both these veins of shale, but especially the thinner one, have a rudely columnar structure at right angles to their direction. Excepting that this shale is a little more indurated and more like slate in its constitution, it is similar to the Cambrian green shales that overlie the basal conglomerate. These veins are in my view undoubtedly part of the Cambrian shale entangled in the granite, so that the granite must be post-Cambrian.

I cannot see any way of escaping from this conclusion. I may add that the conglomerate in contact with the granite, as before described on the opposite side of the valley, is converted into an extraordinarily tough rock. Though I saw no veins of granite penetrating the adjoining rock, I have little difficulty in recognizing these alterations as ordinary contact phenomena.

In the face of this strong evidence to the contrary, it appears to me that the presence of "dirty quartz" in the conglomerate like that in the granite, a resemblance that may be accidental or fanciful, but is much insisted upon by Dr. Hicks, has no great weight in proving that the conglomerate is largely made up of materials from the granite, and that therefore the granite is pre-Cambrian.

NOTICES OF MEMOIRS.

I.—Note on a few of the many remarkable Boulder-stones to be found along the Eastern Margin of the Wicklow Mountains. By Professor Edward Hull, LL.D., F.R.S., Director of the Geological Survey of Ireland.[2]

AMONGST the evidences of the former existence of an extensive sheet of ice descending from the Wicklow Mountains towards the shores of the Irish Sea is the occurrence of boulder-stones, chiefly formed of granite or granitoid gneiss, derived from the mountainous range to the westward, of a size seldom equalled —probably not surpassed—amongst the British Isles. As the Association includes in its labours the task of collecting details regarding erratic blocks, it may prove of interest, if I record a few cases which have come under my own notice.

1. *The Mottha Stone.*—This remarkable boulder is perched on the summit of Cronhane Hill, above Castle Howard, and is a conspicuous object from all directions. It consists of grey granite,

[1] I use the term "vein" because it best describes the form in which these remnants of the shale occur.

[2] Read before Section C. (Geology), British Association, Manchester, Sept. 1887.

and rests upon Lower Silurian slate. Its dimensions are nearly as follows:—length, 14 feet; height, 9 feet; breadth, 9 feet. It contains about 35 cubic yards of matter, and its weight would be about 70 tons. From the site of the Mottha Stone, at a level of 816 feet above the sea, the eye ranges westward along the magnificent valley of Glenmalure, to the flanks of Lugnaquilla, at a distance of about ten or twelve miles, whence, as we may suppose, the granite block started on its journey. In its course it must have crossed the deep hollow of the Avonmore valley, which extends just below the feet of the observer transversely to the path of this remarkable erratic block.

2. *Castle Kevin.*—In the valley between Castle Kevin and Moneystown, where large boulders are numerous, there lies a block of granite, partially imbedded, of which the dimensions are:—length, 15 feet; breadth, 10 feet; height, 9 feet (imbedded portion—probably 3 feet—is not included in above). This block contains about 50 cubic yards of matter, and is about 100 tons in weight. The birthplace of this boulder was probably the mountainous tract about Mullaghcleevann, 2783 feet in height, lying at the head of the valley in which is situated the deep waters of Lough Dan, and it probably travelled a distance of eight or nine miles in an E.S.E. direction.

3. The last boulder-stone that I shall mention is the largest I have met with in co. Wicklow—perhaps in the British Islands. It stands behind a cottage by the roadside, near Roundwood Church, and is quite as large as the cottage itself, to which it forms a good protection from the storms descending from the mountains behind. This boulder consists of granitoid gneiss, resting on Lower Silurian slate and grit. Its dimensions are (q. p.):—length, 21 feet; breadth, 14 feet; height, 12 feet. Its form is somewhat oval, and it contains about 120 cubic yards of matter, and is about 240 tons in weight. The source of this block, which lies at an elevation of about 800 feet above the sea, was probably in the same locality with that of the Castle Kevin boulder, and the distance travelled was about six or seven miles.

The blocks above noticed, with many others of smaller size, do not belong to any of the local glaciers which once filled the valleys towards the close of the glacial epoch, and which have left numerous well-formed moraines in nearly all the principal valleys descending from the Wicklow range. They are to be referred, in all probability, to the earlier stage of intense glaciation, in which the whole district was covered with perennial snows and ice, moving eastward into the hollow now occupied by the waters of the Irish Sea.

II.—On the Reputed Clavicles and Interclavicles of *Iguanodon*.

By Professor H. G. Seeley, F.R.S.[1]

THE author showed, by superimposing a figure of the reputed clavicle upon the bone figured by Mr. Hulke as clavicle and interclavicle of *Iguanodon* (Quart. Journ. Geol. Soc. vol. xli. pl. xiv.),

[1] Abstract of a paper read before the British Association, Manchester, Sept. 1887.

that the supposed sutures are fractures, and that the supposed interclavicle has no existence, except as an ossification posterior to the reputed clavicles. Then it was urged that these bones are unparalleled by any vertebrate clavicles, while the reputed pubes of Crocodiles and pre-pubes of other animals offer a more probable analogy.

The ossification in front of the pubis in *Ornithosaurus* is of similar form in several genera. And in Crocodiles the ossification of the fibrous extension which connects the reputed pubes with the sternal ribs would produce a bone like the supposed interclavicle of *Iguanodon*. Hence it was urged that these bones in *Iguanodon* are pre-pelvic, and the author identified them with the pre-pubic bones.

III.—The Classification of the Dinosauria. By Professor H. G. Seeley, F.R.S.[1]

THE author discussed the structure of the animals named *Dinosauria*, and concluded that the group had no existence, the constituent animals belonging to two orders which have no affinity; they are named *Omosauria* and *Cetiosauria*, the former with a sub-avian pubis and ischium; the latter with those bones sub-lacertilian.

The *Omosauria* is defined as having the ventral border of the pubic bone notched out so that one limb is directed backward parallel to the ischium, while the other limb is directed forward. The ilium has a slender prolongation in front of the acetabulum.

The *Cetiosauria* is defined by having the pubes directed forward with a median symphysis, but with no posterior limb to the bone. The anterior prolongation of the ilium has a vertical expansion.

IV.—On the Mode of Development of the Young in *Plesiosaurus*. By Professor H. G. Seeley, F.R.S.[1]

THIS paper was descriptive of a specimen submitted to the author by J. F. Walker, Esq., F.G.S. It is a phosphatized nodule from the Lias of Whitby, measuring about 10 cm. by 7, by 5. On its surface are four more or less complete specimens regarded as fœtal *Plesiosauri*, together with fragments of at least three others. They are remarkable for having the flesh mineralized with phosphate of lime, and still show many characters of the external form of the body, but slightly distorted by decomposition. Only one individual has the head preserved, its extreme length is about 14 mm. The nares are terminal, like those of an emydian chelonian. The superior aspect of the head behind the frontal bone is occupied by muscular substance. The skull rests on one side against the matrix, so that its transverse width is not clearly shown, but it was wider than the neck, and narrows in front of the orbit towards the nares, which curve a little downward. The eyes look obliquely upward and outward, and have a diameter of two millimetres. The neck has a length of 4·5 centim. Behind the head it is about 4 millim. deep, and as wide; it widens to a centim. where the expansion takes place at the shoulders, and there the depth is about 8 mm. A sharp median ridge down

[1] Extracts of papers read before the British Association, Manchester, Sept. 1887.

the middle of the neck divides its superior aspect into two oblique moderately convex surfaces. Other individuals show that this ridge was prolonged down the back and tail, but less elevated. The body is about as long as the neck. On the right side it has suffered some abrasion and injury in cleaning, and is not quite symmetrical, being a little larger on the left side. It is about 2·4 centim. wide, convex from side to side, and less convex in length. The expansion from the neck is rapid, and attenuation posteriorly is marked so that the body has a long egg shape. The tail appears to be short and conical, and curves rapidly downward in every specimen. The height of the body was not more than half its width. The limbs are imperfectly preserved. The distance between them on the left side is 2·4 centim. The anterior limb appears to be the larger. The entire length of the specimen is 12·5 centim.

This individual lies over the neck of another specimen which was larger, and appears to have measured 15 centim. without the head. It shows the fore limbs to have been very wide relatively to their length, and to have measured in the antero-posterior direction 1·1 centim. at the junction with the shoulder on the right side; it is flattened, extended horizontally, imperfect distally, and curved somewhat backward, but evidently short as compared with the adult. The hind limbs of this specimen are not seen.

Other individuals are smaller, and have the body only about half as wide. They are very narrow in the anterior part of the body, and there appears to be only a slight budding of the fore limbs.

Hence, I regard this specimen as showing that the *Plesiosaurus* was viviparous, and that in one species from the Lias many were produced at one birth. The species was probably a long-necked one, and may have been *P. homalospondylus*, since the head in young animals is relatively large, and here it is ⅓ of the total length of the animal.

V.—Upon a Simple Method of Projecting upon the Screen Microscopic Rock Sections both by Ordinary and by Polarized Light. By E. P. Quain.[1]

KNOWING the difficulty experienced in pointing out to students any particular crystal in a rock-section when viewed with the microscope direct, I attempted to project the images on the screen, and by the aid of comparatively simple apparatus met with very gratifying success, both with ordinary and with polarized light.

The tube of the microscope was screwed out and replaced with a cork, through which a hole had been cut to carry the ordinary one-inch micro-objective and behind it the analyser of the microscope. The polariscope and rock-section occupied their usual position, as when used with the microscope in the ordinary way. The microscope stand being inclined into the horizontal position was placed in front of the object-lens of the lime-light lantern. The object-lens of a lantern usually consists of a combination of two lenses. If so, the back lens is taken out, and the front lens only

[1] Abstract of a paper read before the British Association, Manchester, Sep[illegible]7.

used, acting as an extra condenser, concentrating the light upon the rock-section, and causing it to pass through the polariser and the analyser. A little adjustment of the light was required to get it well through both polariser and analyser, but this with a little care was soon done, and a bright picture several feet in diameter was projected upon the screen, showing the crystals well defined, and exhibiting very strikingly the changes of colour, etc., characteristic of the crystals when viewed by polarised light, and in such a manner as to be well seen by a number of people at once, and also allowing the lecturer to readily point out any particular crystal or crystals to which he desires to draw the attention of his audience.

As the optical axes of the lantern and microscope did not coincide, the lantern was placed on a board provided with four levelling screws with which the necessary adjustments were readily made.

Much better effect may be got if the "Joblowsky" form of prisms made by Zeiss are used instead of the usual Nicols prisms, on account of their greater aperture and shorter length.

VI.—The Permian Fauna of Bohemia. By Prof. Dr. Anton Fritsch, Director of the Royal Bohemian Museum in Prague.[1]

PROF. Dr. Anton Fritsch, of Prague, Bohemia, read a paper on the Permian Fauna of Bohemia. After having mentioned the 73 species of *Labyrinthodonts*, of which he has given figures in his work "Fauna der Gaskohle," and of which he exhibited the electrotypes and restored models in the galleries of the Owens College, he communicated the discovery of a very peculiar genus *Naosaurus* (Cope). He then explained some unpublished plates of *Ctenodus*, *Orthacanthus*, *Hexacanthus*, and a new Ganoid Fish, *Trissolepis* with three kinds of scales. He proved *Acanthodes* to be very near to Selachians, and lastly he drew attention to the gigantic fish (*Amblypterus*) 113 cm. long exhibited in the galleries.

VII.—Report on the Fossil Plants of the Tertiary and Secondary Beds of the United Kingdom. By J. S. Gardner, F.L.S., F.G.S.[1]

THE small balance carried forward from last meeting has been expended in visiting the localities in which fossil plants have previously been met with. The beds near the Pier at Bournemouth seem more than usually inaccessible, but a fall from the cliff has brought down some of the dark clays, and in these were parts of a large feather Palm and other leaves. I was fortunate enough, however, to secure at the west end of the cliffs a new species of *Acer* and a fine leaf of *Dryandra acutiloba*, really a *Myrica*, a rare leaf at Bournemouth, and one of the few that extend upward from the Lower Bagshot into the Bournemouth horizon.

I have again visited Alum Bay, but the pipe-clay on the shore has become still more diminished, and there is no hope that any more fossil plant-remains will be obtained there in our time. No distinct plant-remains are obtainable from the same horizon at

[1] Abstracts of papers read before the British Association, Manchester, Sept. 1887.

Whitecliff Bay, though I had some hope that this might be the case. The drought was unfavourable to collecting at Barton and Hordwell, where most interesting fruits are washed out during heavy rains, and I procured no plants during my visits there this year; but it favoured, on the contrary, collecting at Lough Neagh, by lowering the level of the lake; and I am able to add a new *Pteris*, an exquisitely preserved fruit, and many Dicotyledons to the Flora, and a *Paludina* to the Fauna.

No plant-remains are obtainable this year at Reading, nor do any of the other brick-pits in which plant-remains have occurred seem in exactly a favourable state, at the moment, for collecting, so that it appears undesirable to ask for further grants for this purpose at present. The Lower Eocene Floras are, however, still insufficiently known, and excavations at Bromley or elsewhere in the Woolwich horizon would, I anticipate, yield especially important results. In the mean time, an enormous mass of material has now been accumulated, which will require years of patient research to digest. Advantage has been taken of the presence of that distinguished Palæobotanist, the Marquis de Saporta, at our meeting, to go through the drawings, numbering more than a thousand, that I have already made of the plants so far collected. He is completely astonished at the richness of our Eocenes, and considers them to be unrivalled. The Reading and Bournemouth horizons contain plants which do not appear in Europe until much later Tertiary times, seeming to have passed very slowly across Europe towards Eastern Asia, which may be considered their present home, their chief affinities being with floras indigenous to that part of the globe, rather than with those of America and Australia, as hitherto supposed.

In conclusion, it may be mentioned, that although, owing to the drought and other causes, already referred to, the results of this year's labours have been but small, when contrasted with the magnificent collections obtained in former years; yet, notwithstanding these adverse circumstances, several important additions have been made by me to the palæophytological collections in the British Museum which will doubtless prove of good service in elucidating the Eocene flora of Britain.

REVIEWS.

LES EAUX SOUTERRAINES AUX ÉPOQUES ANCIENNES. Par A. DAUBRÉE, etc. One Vol. pp. 443, with numerous Illustrations. (Vve. Ch. Dunod, Éditeur, Paris, 1887.)

THIS work treats of the part which underground waters have played in the origin and modification of the substance of the Earth's crust. In the preface Mons. Daubrée alludes to the ideas of Bernard Palissy and others as to the analogy which exists between what we should call organic and inorganic bodies, and to the belief that the latter possess a sort of quasi-vitality. Questions bearing on this subject have lately attracted the attention both of the President of the Geological Society and the Editor of this MAGAZINE. It is

quite sufficient for our present purpose that water should be deemed an important agent in causing "stones to grow." But a few years have elapsed since a celebrated geological chemist declared that the alkahest, or universal menstruum, was neither more nor less than water, aided by heat, pressure, and the presence of other substances. The author of the work now under consideration has already demonstrated in his celebrated "Études synthétiques" the important part played by underground waters charged with various substances in the formation of minerals; and he now proceeds to point out how their history furnishes us with a remarkable example of the continuity of operations past and present. Even in places where they no longer flow, these underground waters have left us indications of their movements and their chemical energy, so that we are enabled to follow them in all the details of their "régime."

Of all mineral substances which have been formed in the wet way, zeolites are amongst the most obvious, and Mons. Daubrée has elsewhere observed that these may be regarded as a kind of extract of the rocks, which have themselves been subjected to continued lixiviation. Entering more fully into this question in the present work, he gives examples of their development and mode of formation, together with that of the associated minerals, quartz, agate, and chalcedony. There is no lack of appropriate illustrations: the section of an agate is particularly fine. He still seems to regard the canal shown by some of them as an inlet of infiltration. The zeolitic minerals of Plombières are discussed at some length: sections of the zeolite-bearing bricks are given, effective alike for showing the minerals themselves as well as the structure of the brick. The bricks thus transformed present considerable resemblance to certain altered volcanic rocks. The siliceous products of the bricks resemble, he says, the acid rocks, whilst the zeolites and globules of palagonite in these same bricks recall the basic rocks. All these changes have been effected since the days of the Romans by waters of a moderate temperature.

The study of the formation of metalliferous deposits affords still more remarkable testimony alike to the solvent and depositing powers of underground waters. Substances, which under ordinary conditions are regarded as insoluble, have been deposited in various ways, as in veins, segregations, beds, etc. *A propos* of this subject Mons. Daubrée does not fail to point out the celebrated instance at Bourbonne-les-bains, so well described in the "Études synthétiques," where old Roman coins by their decomposition have yielded metallic sulphides under the action of warm mineral waters.

This branch of the question is a very large one, and has received ample treatment both from Mons. Daubrée, and also from the late John Arthur Phillips, in his excellent treatise on "Ore Deposits." One cannot fail to perceive that these authors are disposed to ascribe the bulk of the phenomena, as regards veins, segregation-veins, beds, etc., mainly to the action of waters, warm or cold. It is true that such actions are often the most powerful in the neighbourhood of eruptive rocks, which are frequently accompanied by veins

having a concretionary structure, either metalliferous or sterile. "This is not so much an immediate product of the rocks themselves as a gentle and prolonged deposit proceeding, some from gaseous emanations, others and these the most numerous from powerful mineral and thermal springs, whose first origin must be attributed to the appearance of the eruptive masses, and whose circulation is effected by the aid of the cracks or fractures of the ground" (Daubrée, *op. cit.* p. 143). There can be no better proof of the intimate connection between mineralizing waters and metallic veins than is afforded by the wonderful phenomena of the Steamboat Springs in Nevada, of which a notice was given in the Quarterly Journal of the Geological Society by William P. Blake as long ago as 1864. Since then the whole of this Comstock region has been the subject of numerous memoirs. According to Mr. Phillips (Ore Deposits, p. 532), these rocks have been carefully assayed, with the results that the neighbouring diabase contains a notable amount of the precious metals, of which the larger proportion is contained in the augite; that the decomposed diabase contains about one-half as much of these metals as the comparatively fresh rock; and that the relative quantities of gold and silver, both in the fresh and decomposed diabase, correspond fairly well with the known composition of the Comstock bullion. There does not seem any reason why these facts should exclusively favour the theory of lateral secretion, but they serve to confirm the notion as to the eruptive rocks being, in this case, the primary source of the metallic wealth of the country, which has been extracted and concentrated, as it were, for the benefit of miners by the aid of heated and mineralized waters, in such fissures as the Great Comstock Lode, where the process may still, to a certain extent, be in operation.

The replacement of limestone by ironstone, and the phenomena connected with iron deposits generally, are also fully treated by the author, who reproduces some of Mr. Kendall's sections showing the mode of occurrence of hæmatite in Cumberland and North Lancashire.

Next comes the question of the change in rock-masses on a large scale—and firstly, as to the mineralization of fossils, and the formation of nodules (rognons), etc. There can be no difficulty in believing that water, in conjunction with dissolved salts and gases, has replaced shell substance by a more or less pure mineral calcite, and that sometimes the replacing substance has been silica, carbonate of iron, or other mineral, even specular iron, as some bivalves he mentions in the Lias. The numerous silicified woods also find a place here. The flints of the Chalk he treats as concretionary bodies, and he gives a telling figure of orbicular silex as developed in the shell of a *Gryphæa*. The chemical alteration of silicated rocks is next dealt with; and here Mons. Daubrée observes with regard to the kaolinization of felspar, that this has not in all cases been effected by surface agents; he suggests aqueous and other emanations in connection with the deposits of tin-ore.

A considerable number of pages are devoted to the great question

of metamorphism. With respect to contact metamorphism, it is not quite clear how far the results, in all cases, have been brought about through the agency of water. Of course, where quartz and numerous anhydrous silicates have been developed in a limestone, which itself has become crystalline in the vicinity of an eruptive rock; supposing such a limestone to have been a nearly pure calcareous rock originally, the ingredients of so many silicates have in all probability been introduced by the agency of waters which owed their impregnation in part to the eruptive rock itself. In dealing with the far more important subject of regional metamorphism, we gather in the first instance that the author excludes the great fundamental gneisses. Although the subject is very fully treated, it is not easy to assert what part water is considered to have played in producing the results; undoubtedly heat, pressure, and and chemical solvents are required in addition to mere water. After the admirable experiments detailed in the "Études synthétiques," and repeated here with excellent illustrations, it has been abundantly shown that anhydrous silicates can be produced in the wet way. Perhaps this is even more than is required in some cases, since the phyllades of the Ardennes are largely composed of such hydrous minerals as sericite and chloritoid, or chlorite, in addition to quartz. We have also the general statement (p. 375) that the water enclosed in clays, combined and fixed, has had a "preponderating action in the development of metamorphic phenomena."

Lastly, Mons. Daubrée considers the light which past and present phenomena are able to throw upon each other. He alludes to the great vertical and horizontal extent over which the course of ancient waters is often discernible. Measured by the standard of historical time, existing hot springs enjoy a great stability, though in general the old thermal springs, which have brought the metallic minerals and their gangues into the veins of so many regions, are now dried up. The relative geological age of ore-deposits is discussed, ranging from the great iron-masses of Scandinavia contemporary with the gneiss, to the Tertiary deposits of Comstock, associated with trachytic greenstone.

He concludes as follows:—"It is thus that water has played a unique part throughout all time in the earth's crust; aided, it is true, by secondary substances, it has been the chief *mineralizer*, even for minerals such as quartz and the anhydrous silicates in whose presence it is altogether inactive at temperatures which prevail on the surface of the globe, and whose origin for this reason was for long time considered beyond its influence.

"However, this does not concern the past merely. There is nothing to prove that operations of this nature are arrested. On the contrary, it is more than probable that, as each day goes by, similar actions are contributing to the formation of new minerals; but these take place in interior regions which are not accessible to our observations. In descending but a few mètres from the surface we find silicates of the family of the zeolites and combinations of sulphides similar to those of metallic veins. Unfortunately we cannot observe the products of reactions which take place of necessity lower down

in the ascending conduits of these springs or in proximity to the laboratories of volcanoes. Superheated water, which betrays itself outside by thermal springs and volcanic exhalations, must produce slowly and silently in the interior of the globe effects both considerable and permanent and, as formerly, give birth to various minerals.

"In its ceaseless circulation subterranean and deep, and by its work principally chemical, water simulates a kind of vital action which is perpetuated in the earth's crust throughout the ages of our planet." W. H. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

November 9, 1887.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "Note on the so-called 'Soapstone' of Fiji." By Henry B. Brady, F.R.S.

The Suva deposit, which has a composition very similar to that of the volcanic muds at present forming around oceanic islands in the Pacific, is friable and easily disintegrated. The colour ranges from nearly white to dark grey, the mass being usually speckled with minerals of a darker hue. Under the microscope the rock presents the character of a fine siliceous mud with crystals of augite, etc., together with the sparsely scattered tests of Foraminifera. The approximate chemical composition of typical specimens is:—Silica, 50 per cent.; alumina, 18 per cent.; lime and magnesia, from 5 to 6 per cent.; ferric oxide, from 3 to 8 per cent.; water, 16 per cent. with a small proportion of alkalies, chiefly potash, and but small trace of carbonates.

The author's attention was chiefly directed to the common grey friable rock, which may be softened in water and washed on a sieve, the residue consisting mainly of Foraminifera with a few Ostracoda. Of three specimens examined, 1 is a light-grey rock from close to the sea-level; 2, of a lighter colour, from about 100 feet elevation; 3 is nearly white and somewhat harder, and was derived from an intermediate point. So far as the Microzoa are concerned, the first two present no differences which might not be observed in dredgings from the recent sea-bottom, taken at similar depths a little distance apart. The third appears to have been deposited in somewhat deeper water. There is a marked scarcity of arenaceous Foraminifera.

Then followed notes on the rarer and more interesting species, together with a list of the 92 species of Foraminifera found. Of these, 87 are forms still living in the neighbourhood of the Pacific islands. Two of the remaining 5 are new to science, and the rest extremely rare. The author concluded that these deposits are of Post-Tertiary age, formed at depths of from 150 to 200 fathoms in the neighbourhood of a volcanic region. The following new or little-known species were selected for illustration:—*Ellipsoidina ellipsoides*, var. *oblonga*, Seguenza; *Haplophragmium rugosum*, D'Orb.; *Ehrenbergina bicornis*, nov.; *Sphæroidina ornata*, nov.

2. "On some Results of Pressure and of Intrusive Granite in Stratified Palæozoic Rocks near Morlaix, in Brittany." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

The author briefly described the banded Palæozoic slates in the neighbourhood of Morlaix, and gave a general account of their microscopic structure. They are greatly contorted and folded, and have evidently undergone very severe pressure. The result of this, as it appears to him, has been the development of minute scales of a light-coloured mica, especially in the darker (originally argillaceous bands) and certain corresponding changes in the more quartzose layers. The cleavage-planes often cut the surfaces of bedding and of this micro-foliation, which are parallel, at high angles, and so are of the nature of "*Ausweichungsclivage*."

In certain places these banded slates, after they have attained the aforesaid condition, have been affected by intrusive granites. The result has been the intensification of the changes which were already incipient. The quartz granules have been doubled in size, the flakes of mica have become four or five times as large, the black material of the argillaceous bands has been gathered into larger granules, and seemingly reduced in quantity (probably by partial oxidation of the carbon), and in some cases andalusite crystals or grains of considerable size have been developed. The rock has become comparatively hard, instead of friable, and the cleavage-planes are "soldered up" by the development of mica along them. In its general aspect one of these banded rocks (where free from andalusite) bears considerable resemblance, macroscopic and even microscopic, to one of the less coarsely crystalline, distinctly banded mica-schists, supposed by many to occupy a rather high position in the Archæan series.

3. "On the Position of the Obermittweida Conglomerate." By Prof. T. McK. Hughes, M.A., F.G.S.

The author gave an account of a visit to the section at Obermittweida, 50 miles S.W. of Dresden, where there is an apparent intercalation of conglomerate and sandstone in a gneissic series. West of the stream at Obermittweida there is seen a crushed but not much altered conglomerate of felsite and other pebbles, above which gneiss and mica-schist rest, apparently in true sequence numerically. Below the conglomerate no rocks were seen, but at a little distance to the eastward coarse flaked muscovite-schists and gneissic rocks were exposed, apparently underlying it. By a diagram the author showed how the conglomerate might belong to much newer beds caught in a synclinal fold of the schists, and he advanced various arguments in support of this explanation.

4 "On the Obermittweida Conglomerate: its Composition and Alteration." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

The author is indebted to Professor Hughes for the opportunity of examining a fine series of specimens of this rock, collected by the latter. The pebbles vary from well-rounded to subangular, some of the smaller fragments occasionally being practically unworn. The matrix is sometimes granular to the unaided eye, sometimes

very fine. The whole mass has evidently been subjected to considerable pressure.

The associated gneiss is a moderately coarse gneiss, containing two micas and garnet. It has a general resemblance to rocks which, in the Alps, appear to occur about or rather below the middle of the crystalline series.

The fragments consist of various kinds of rocks. Those examined microscopically are referred to granitoid rock (3 varieties), mica-schist, quartz-schist, quartzite, hälleflinta (?).

The matrix is almost wholly composed of quartz and mica (two species, but mostly brown), with some felspar. The materials appear to have undergone a certain amount of metamorphism, by augmentation of the original fragments, and to some extent by development of new minerals. The author is of opinion that the materials are rather more altered than is usual in Palæozoic greywackes and conglomerates, but that the comparatively small amount of alteration, and the character of the included fragments, render it highly improbable that the conglomerate is in stratigraphical sequence with the above-described gneiss, or with any similar series of rocks; and so, if Archæan, it must belong to one of the latest epochs in that period.

5. "Notes on a part of the Huronian Series in the Neighbourhood of Sudbury (Canada)." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

The specimens noticed by the author were in part collected by him in the summer of 1884, when the Canada Pacific Railway was in process of construction, and in part subsequently supplied to him by the kindness of Dr. Selwyn, Director-General of the Geological Survey of Canada.

The eastern edge of the district assigned to the Huronian consists of rocks, which may possibly be part of the Laurentian series modified by pressure. But after crossing a belt of these, barely a mile wide, there is no further room for doubt. All the rocks for many miles are distinctly fragmental, except intrusive diabases or diorites. These fragmental rocks are grits, conglomerates, and breccias, which are described as far as about two miles west of Sudbury. The included fragments in these rocks appear to have undergone some alterations subsequent to consolidation: these are described. In some cases the changes appear to be anterior to the formation of the fragments. The matrix also has undergone some change, chiefly the enlargement of quartz grains, and the development or completion of mica-flakes, as in the Obermittweida rock.

The author gave some notes on other specimens collected by him along the railway, further west, and on those supplied to him from near Lake Huron by Dr. Selwyn. As a rule these are but little altered. Some contain fragments of igneous rocks, apparently lavas.

The author discusses the significance of the changes in these rocks, as bearing on general questions of metamorphism, and states that, in his opinion, the name Huronian, at present, includes either a series of such great thickness that the lower beds are more highly altered

than the higher, or else two distinct series; and he inclines to the latter view. Both, however, must be separated from the Laurentian by a great interval of time, and neither exhibits metamorphism comparable with that of a series of schists and gneisses, like the so-called Montalban. The newer reminds him often of the English Pebidians.

CORRESPONDENCE.

LYDEKKER, BOULENGER, AND DOLLO ON FOSSIL TORTOISES.

Sir,—I have read with interest the notes on the above subject which appeared in the Geological Magazine for June and September, I find that the two first-named gentlemen have overlooked a paper of mine, which will relieve me of the charge of erroneous treatment of the genus *Pleurosternum* which they make. The paper was published in 1870,[1] and prior to those of Professor Rütimeyer which they cite as authority for determination already made by me. The learned authors quote me as stating that in the genus *Pleurosternum* there is "no intergular shield, and the genus is accordingly referred by me to the Cryptodira; whereas its true position, as was pointed out by Prof. Rütimeyer, is with the Pleurodira; and with that group—the Pelomedusidæ and Peltocephalidæ of Gray—characterized by the presence of eleven, instead of nine, plastral bones." On a subsequent page (274–5) they consider the *Platemys Bowerbankii*, of Owen and Bell, "in regard to which Prof. Rütimeyer has already pointed out that the specimen figured by the same writers under the name of *Emys lævis* is merely the young of the former, and that owing to the presence of a small mesoplastral bone, the reference to *Platemys* is incorrect, and it is suggested that the species may probably belong either to *Podocnemis* or *Peltocephalus*."[2]

In my paper of 1870 I remark, "The genus *Platemys* as adopted [in Maack's work] may be cited. It embraces nine species according to the present work, the genus *Pleurosternum* of Owen being referred to it. This is done because the additional pair of thoracic bones which characterizes it is found in a rudimental condition in *Platemys Bowerbankii*; and *Platemys Bullockii* of Owen presents the intermarginal scuta of *Pleurosternum*, and because of the general resemblance in specific characters between the latter and the *Pl. concinnum*. To us, however, the genus *Pleurosternum* appears to be Cryptodire, not Pleurodire, as it lacks the intergular scutum of the later suborder, and to represent a peculiar family of that group characterized by the possession of ten instead of eight sternal bones. *Platemys Bullockii*, *P. Bowerbankii*, and *Emys lævis*, Owen and Bell, appear on the other hand to be Pleurodira, and to be referable to two families of that suborder. The *Pl. Bullockii*, on account of its five pairs of sternal bones, to the Sternothæridæ, and on account of

[1] Die bis jetzt bekannten Schildkörten, u. d. bei Theilheim in Hannover neu afgefunden altesten Arten derselben; von Dr. G. A. Maack; a review by E. D. Cope, Amer. Journal Sci. Arts, 1870, L. pp. 136.

[2] "The figure shows that its affinity appears to be rather with the former than the latter, and it may accordingly be provisionally referred to that genus."

its intermarginal scuta to a new genus, which I call *Digerrhum*. The last two in their rudimental fifth pair of sternals, resemble many *Pleurodira*, and cannot be distinguished from the genus *Podocnemis* now living in the Amazon."

In this paragraph I have made the references adopted by Rütimeyer, Lydekker and Boulenger, but I did not use the name *Pleurosternum* for the *Pl. Bullockii*. Believing that the *Pl. concinnum* represented that genus, I removed the *Pl. Bullockii* from it. It now remains to ascertain the characters of the *Pleurosternum concinnum*, since no reference is made to it by the authors of the paper on which I am now commenting, but who regard the *Pl. Bullockii* as typical of the genus.

M. Dollo well remarks (September Number) that the absence of dermal sutures cannot alone place a genus of Tortoises in a separate family from forms which possess such sutures. He regards *Erquilenesia* as most resembling *Euclastes*, but not to belong to the Propleuridæ. But I think *Euclastes* is one of that group, and I suspect that Dollo's characters of the skull define the group better than the number of costal bones, which will however distinguish the genera.

E. D. Cope.

ORIGIN OF CERTAIN BANDED GNEISSES.

Sir,—Mr. Teall's paper on the origin of certain banded gneisses (p. 484) is a contribution of the utmost value to the discussion of a very difficult subject. But, as I am responsible for another theory concerning these gneisses, may I be allowed to say, that though I admit the importance of the hypothesis, I still see great difficulties in the way of accepting it. These gneisses of the Lizard must not be regarded alone; a hypothesis which might alleviate our difficulties here (and they are undoubtedly great) might increase them elsewhere—and thus, did I assign an igneous origin to all the crystalline rocks south of St. Keverne, I should find it difficult to know where to stop in applying the explanation to other regions. Moreover, if we are to explain these banded gneisses as the rolling or crushing out of a complex of igneous rocks, not only must the flexibility of the rocks have been very great, but also this complex originally must have been a very intricate one. Now I have had a fairly large experience in the habits of igneous rocks, and, so far as this goes, such complications as would be required here are both rare in occurrence and limited in extent. Yet at the Lizard the banded series is of considerable thickness, and can be traced along the coast for full two miles. I admit, however, that when I wrote my two papers, I sometimes failed to distinguish between structures significant of original constitution and those due to subsequent mechanical action, for our knowledge of the latter is of very recent date; but to what extent I will not venture to say until I can again examine the whole district. This I hope to do, but for various reasons must defer the pleasure for a time. Probably it will be some years before we can fairly determine the claims of conflicting hypotheses; meanwhile it is well for science that Mr. Teall has advanced one with so much moderation in statement, and clearness in reasoning. Perhaps

one day he may claim me as a thorough-going convert; but at present I anticipate that it will be my ultimate fate here, as in other things, to maintain that truth lies between opposite extremes.

As I am writing, I may as well briefly notice another criticism on some work of mine in the south-west. In the Transactions of the Devonshire Association a paper has recently appeared (p. 349), advocating the old view of a gradual transition between the slaty and the crystalline series in the Start and Bolt Head districts. As the writer has "to confess to much ignorance as to the methods and results of microscopic research," and the question is one in which such methods are essential in order to distinguish real differences, and avoid being misled by superficial resemblances, I cannot admit that he is qualified to investigate the subject, or waste time by discussing it with him, and will only say, that, though since I wrote the paper I have frequently examined my specimens and slides, I have seen no reason to alter my opinion as to the separateness of the two groups of rocks. Moreover, a paper will shortly appear in the Quarterly Journal of the Geological Society, by a careful observer in the field and worker with the microscope, in which much additional evidence is brought forward in favour of my view. It would be thought strange if any one were to enter into a dispute as to the interpretation of a corrupt passage in a chorus of a tragedy of Æschylus, without a preliminary study of the niceties of the Greek language; yet this is the course which some persons follow in petrology, and seem to think that thereby they are doing a service to science.

T. G. Bonney.

OBITUARY.

REV. W. S. SYMONDS, M.A., F.G.S.

Born 1818; Died 1887.

Forty years ago, the promotion of Natural Science throughout the country was mainly entrusted to the agency of the various local Field Clubs and Natural History Societies, amongst the most active and useful of which may be mentioned the Malvern Natural History Field Club, the Woolhope Naturalists' Field Club, and the Cotteswold Club. It was in the districts over which these clubs held sway that the subject of our present notice passed the best years of his life and carried on those geological labours with which his name will always stand associated.

Mr. Symonds was born at Hereford in 1818, being the son of William Symonds, Esq., of Elsdon, Herefordshire. After passing through his school-days with Mr. Allen at Cheltenham, and reading with the Rev. J. P. Sill, he was sent to Christ's College, Cambridge, where Sedgwick was then in the height of his popularity as a geological lecturer. He took his degree in 1842, and in 1843 he was appointed Curate of Offenham, near Evesham, where he became acquainted with Mr. Hugh Strickland, from whom he received many of his first lessons in Natural History. In 1845 he was presented to the Rectory of Pendock, near Tewkesbury.

Mr. Symonds married, in 1840, Hyacinth, daughter of Samuel Kent, Esq., of Upton-on-Severn, and had issue three sons and one daughter; the latter only now survives him, and is married to Sir J. D. Hooker, K.C.S.I., F.R.S.

From an early date Mr. Symonds became the friend and associate of Sir William Vernon Guise, Bart., of Elmore Court, near Gloucester, and it is significant that the two attached friends died within a few days of one another, viz. 15th and 24th Sept. (see GEOL. MAG. Nov. 1887, p. 528).

Mr. Symonds assisted in the foundation of the Woolhope Naturalists' Field Club, and was elected its President in 1854. He was also President of the Malvern Naturalists' Field Club from 1853 and for many years subsequently.

In 1857 he visited Dublin, in order to attend the Meeting of the British Association, and availed himself of the opportunity to make a geological tour through Ireland (see Geologist, 1858, pp. 292-296 and 330–335). In this year he also published a work entitled "Stones of the Valley."

In 1858 we find him busy in the field exploring the bone-bed of the Upper Ludlow rocks and their characteristic fossils (Geologist, 1858, p. 15). Mr. Symonds examined in 1859 the reptiliferous sandstone near Elgin (see Edinburgh New Phil. Journ. 1860, vol. xii. p. 95), and in the year following he was watching the results of the geological sections exposed in the Malvern and Ledbury Tunnels with Mr. A. Lambert (Geologist, 1861, p. 148). In 1863 he made a geological ramble through Wales, an account of which he communicated to the Worcester Nat. Hist. Soc. Trans. 1864. A new edition of his book entitled "Old Bones, or Notes for young Naturalists," was issued in 1864, the first edition having appeared in 1859.

In the summer of 1866, accompanied by his friend Sir W. V. Guise, Bart., Mr. Symonds visited Belgium, and under the guidance of Prof. Dupont, explored the Bone-Caverns of the Valley of the Lesse, and gave an interesting description of the same to the Woolhope Naturalists' Field Club (GEOL. MAG. 1866, pp. 564–570).

In 1871 Mr. Symonds published, in Dr. H. Woodward's Monograph on the Merostomata, some interesting Notes on Silurian localities in the West of England where these fossil Crustacea occur (see Pal. Soc. Mon. Brit. Foss. Crustacea, 1871, part iii. pp. 92–104). In the same year Mr. Symonds explored the Hyæna-Den (known as King Arthur's Cave) on the Great Doward, Whitchurch, Ross (see GEOL. MAG. Vol. VIII. p. 433).

In the year following (1872) he brought out his "Record of the Rocks," an excellent and readable handbook for students of the Geology of the West of England.

The autumns of 1874, 5, and 6, were spent in company with Sir Wm. Guise, Mr. Lucy, and others, in exploring the volcanoes and tracing the ancient glaciers of Auvergne and those of the Haute Loire and the Ardèche (see the Pop. Sci. Rev. vol. xv. 1876, and N. Ser. vol. i. pp. 1, 250, 329, 1877).

In 1880 Mr. Symonds published a second edition of his book

entitled "Old Stones," and also his romance of "Malvern Chase," which reached a third edition in 1883. In this year he issued two more works, namely, "Hanley Castle," a romance; and the "Severn Straits," a geological work. Althogether he was the author of more than forty papers which have appeared in various scientific journals.

The main object of Mr. Symonds' active and useful career, and to the furtherance of which all his best energies were directed, was the promotion of a love for Geological, Botanical, and Archæological pursuits and studies, amongst the very large circle of educated people in the West of England by whom he was surrounded, whose tastes he strove to elevate and direct, and whose leisure hours he endeavoured to occupy with healthful and intellectual pursuits.

Although a clergyman and a Justice of the Peace for the county of Worcestershire, he was above all things an ardent Naturalist and Geologist, and he was never so happy as when conducting the members of his own Naturalists' Field-clubs over some classical region in "Siluria," with every spot of which he was familiar.

For several years before his death he had been compelled by ill-health to withdraw from his parish duties, but he remained as full of interest in all scientific matters as ever to the last.

Mr. Symonds died on the 15th September, at Cheltenham.

His loss, like that of his friend Sir W. V. Guise, will long be felt in the West of England, where the services and presence of both had exercised so beneficial an influence over a very wide and intelligent community for nearly half a century.—H.W.[1]

August Friedrich Count Marschall, of Burgholzhausen and Tromsdorf, who has frequently contributed to the Geological Magazine, as well as to the Quart. Journ. Geological Society, notes on Geology and Palæontology, especially from the researches of his Colleagues in Vienna, died suddenly on the 11th of October, in his 83rd year. He was a Foreign Correspondent of the Geological Society of London, and Correspondent and Member of many other learned Societies,—also Hereditary Marschal in Thüringia, Imp. Roy. Chamberlain, and formerly Archivist of the Imp. Roy. Geological Institute of Vienna. His frequent communications on papers read at the Academy, Institute, and other Societies, forwarded by him to various European friends and periodicals, were continued with his usual industry (his motto being "Nunquam otiosus") to within a short time of his death. His "Nomenclator zoologicus," combining both recent and fossil genera, published by the Zoologico-Botanical Society of Vienna in 1873, is a very valuable book of reference; and the "Ornis Vindobonensis," 1882, is written in conjunction with Dr. A. von Pelzeln, also bears evidence to our deceased friend Count Marschall's scientific zeal and usefulness.—T. R. J.

[1] We regret to record the death, on October 4th, at Tonga, of Mr. H. F. Symonds, only remaining son of the late Rev. W. S. Symonds. He was Consul at Samoa and Deputy Commissioner of the Western Pacific. He was only 32 years of age and a man of great promise.

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STEPHEN AUSTIN AND SONS, PRINTERS, HERTFORD.